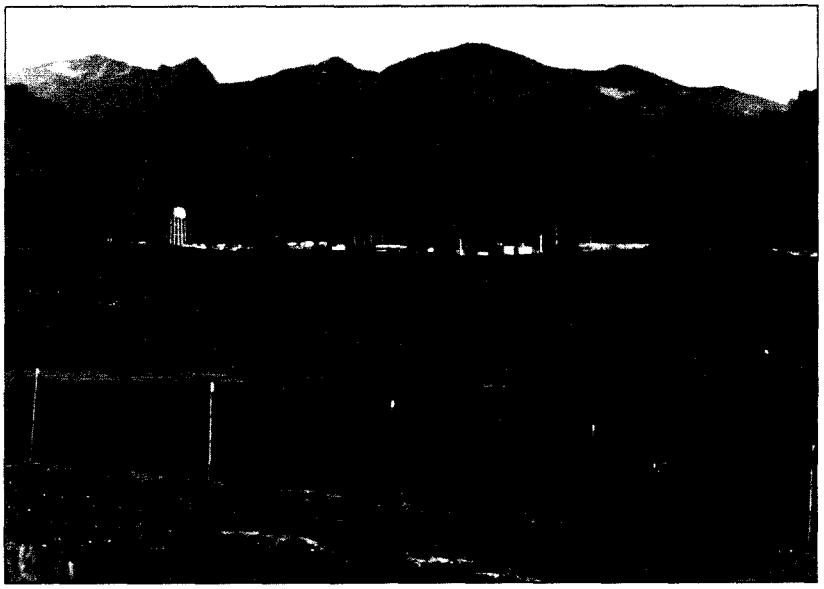

ROCKY FLATS PLANT SITE ENVIRONMENTAL REPORT

JANUARY THROUGH DECEMBER 1992

EG&G ROCKY FLATS

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DISCLAIMER

RFP-ENV-92

ROCKY FLATS PLANT SITE ENVIRONMENTAL REPORT FOR 1992

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ABOUT OUR COVER

The Rocky Flats Plant is a government facility in transition. Its former production mission, once crucial to the nation's defense system, came to an end in 1992 with the end of the Cold War and the U.S. Government's decision not to resume weapons component production activities at the plant. Today, Rocky Flats is transitioning to a new mission focusing on environmental restoration, waste management, and decontamination and decommissioning of facilities. The photographs illustrated on the cover of this report represent three important aspects of the plant's past and present missions, ranging from the general production facilities pictured in the top photograph, to the employees who fulfilled a vital role in the plant's national defense mission. Those same employees are now being called upon to provide the experience and knowledge necessary to successfully complete the transition to a new mission while protecting employee and public health, and restoring and preserving the unique environment that surrounds the Rocky Flats Plant.

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PREFACE

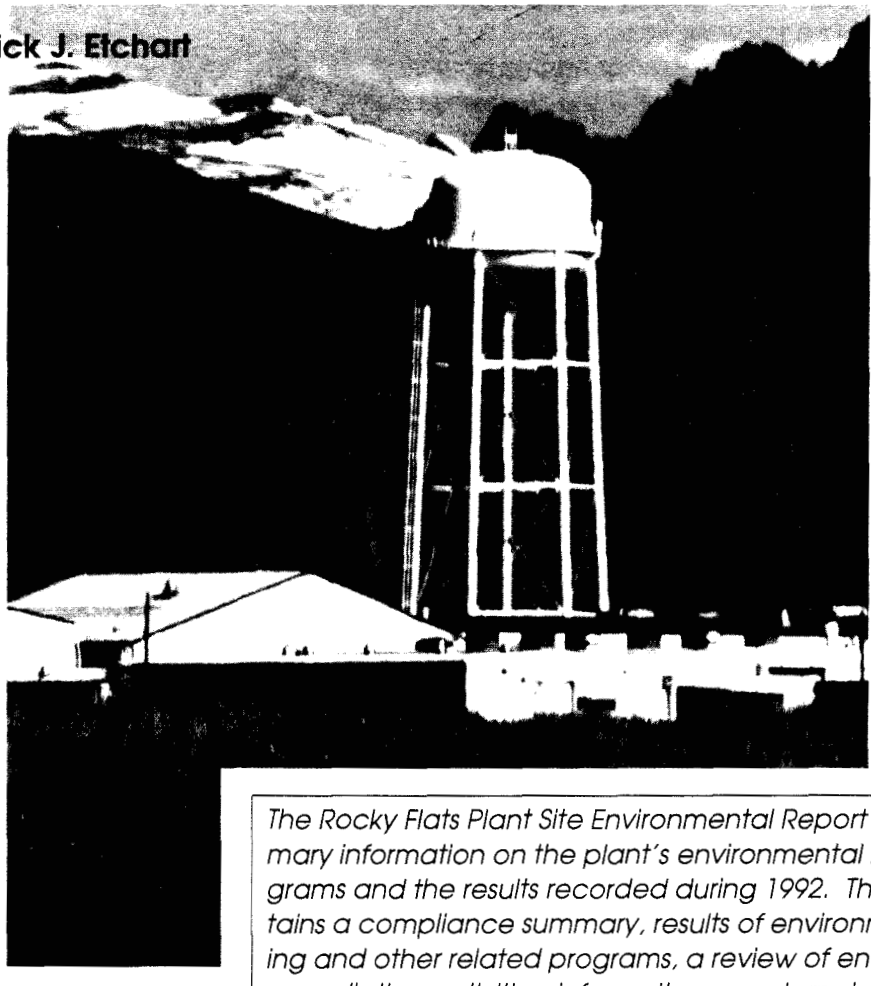
The 1992 *Rocky Flats Plant Site Environmental Report* provides information to the public about the impact of the Rocky Flats Plant on the environment and public health. The report contains a compliance summary, a description of environmental monitoring programs, and radiation dose estimates for the surrounding population for the period January 1 through December 31, 1992.

An environmental surveillance program has been ongoing at the Rocky Flats Plant since the 1950s. Early programs focused on radiological impacts to the environment. The current program examines the potential radiological and nonradiological impacts to air, surface water, groundwater, and soils. It also includes meteorological monitoring, ecological studies, and environmental remediation programs.

Environmental operations at the Rocky Flats Plant are under the jurisdiction of several local, state, and federal authorities, particularly the Colorado Department of Health, the Environmental Protection Agency, and the Department of Energy. A variety of reports are prepared at different intervals for these and other agencies in addition to the annual environmental report. A list of these reports is provided in Section 3, Table 3-1.

Executive Summary

Patrick J. Etchart



The Rocky Flats Plant Site Environmental Report provides summary information on the plant's environmental monitoring programs and the results recorded during 1992. The report contains a compliance summary, results of environmental monitoring and other related programs, a review of environmental remediation activities, information on external gamma radiation dose monitoring, and radiation dose estimates for the surrounding population. This section provides an overview of these topics and summarizes more comprehensive discussions found in the main text of this annual report.

OVERVIEW

The purpose of the Rocky Flats Plant Site Environmental Report is to present summary environmental data to help characterize site environmental management performance, confirm compliance with environmental standards and requirements, and highlight significant programs and efforts. This report represents a key component of the Department of Energy's (DOE) effort to keep the public informed about the environmental condition at the Rocky Flats Plant (RFP). The Site Environmental Report helps characterize both the radiological and nonradiological condition of the site environment and helps identify trends with regard to effluent releases and environmental conditions.

This Executive Summary provides an overview of the report including a compliance summary for activities related to environmental statutes, regulations, orders, and agreements. Section 3 of this report provides a discussion of environmental monitoring programs at RFP and includes data on meteorological, air, surface water, groundwater, soils, and ecological monitoring. Environmental Remediation programs are reviewed in Section 4, followed by discussions on external gamma radiation dose monitoring and radiation dose assessment. Section 7 includes a review of the RFP's Quality Assurance program. Four appendices provide additional information on applicable guides and standards, analytical procedures, wind stability classes, and the basic concepts of radiation to assist in the understanding and interpretation of monitoring information and radiation dose assessment.

More comprehensive discussions on each topic can be found in the main text of this report.

COMPLIANCE SUMMARY

National Environmental Policy Act (NEPA)

The National Environmental Policy Act (NEPA) is the nation's most widely applied federal environmental statute, requiring documentation that shows federal agencies have considered environmental impacts and public commentary on proposed actions. During 1992, the RFP NEPA Compliance Committee (NCC) provided information and recommendations on approximately 120 projects related to construction, refurbishment, or upgrades of RFP facilities.

Progress continued on preparation of Environmental Assessments (EAs) for a new Sanitary Landfill and for Surface Water Structures Maintenance. An EA is prepared to determine whether a proposed federal action requires preparation of an Environmental Impact Statement (EIS). Before preparation of an EA, the proposed federal action is evaluated as a possible Categorical Exclusion (CX), which is a category of actions that do not have a significant effect on the human environment and do not require either an EA or an EIS. Twenty CXs were approved during 1992.

Endangered Species Act, Fish and Wildlife Coordination Act, Migratory Bird Treaty Act, and Executive Order 11990 (Protection of Wetlands)

Several Public Notices of Wetland/Floodplain Involvement and Statements of Findings were published in the Federal Register as required by 10 CFR 1022. Among those were the Sitewide Treatability Study; Well Plugging and Abandonment Program; Site Characterization Activities at Operable Units (OUs) 1, 2, 5, and 6; Proposed Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Characterization and Remediation Studies in OUs 3, 4, 7, and 9; and Surface Water Monitoring Station Upgrades and Installations.

Clean Air Act (CAA)

The Environmental Protection Agency's (EPA) National Emissions Standards for Hazardous Air Pollutants (NESHAPs) established an annual limit of 10 millirem per year (mrem/yr) effective dose equivalent (EDE) to any member of the public as a result of a facility's operations. Radionuclide air emissions from RFP were well within the required limits during 1992.

RFP's radionuclide emissions monitoring systems are not in full compliance with EPA's monitoring requirements; however, the existing monitoring deficiencies are not likely to cause emissions to be underestimated. RFP is responding to a Compliance Order (issued to RFP by EPA Region VIII) that requires compliance with the effluent monitoring requirements of 40 CFR 61.93(b).

The calculated beryllium discharged from RFP during all of 1992 was 3.399 grams (g), compared to the daily stationary source limit of 10 g over a 24-hour period set by Colorado Air Quality Control Commission Regulation No. 8.

Air Pollutant Emission Notices (APENs) are required by Colorado Air Quality Control Commission Regulation No. 3 for all sources that generate regulated nonradionuclide air pollutants. The air pollutant emissions reported on the source-specific APENs comprise the nonradionuclide air emission inventory for RFP. The baseline air emission inventory was completed in 1990-91. During 1992, six APEN reports were submitted to the State for significant new or modified operations: Outside Industrial Storage Tanks (4/92); Building 664, Solid Waste Disposition Center (3/92); Operable Unit 1, 881/891 Hillside Remediation (3/92); Building 771, Solution Disposal Plan (5/92); Building 928, Firewater Diesel Pump; and Building 779 Complex (1/92). The APEN report for Building 779 was rewritten at the request of the Colorado Department of Health, Air Pollution Control Division (CDH, APCD), to conform to the reporting format established during the 1990-91 baseline inventory.

In response to new provisions in the 1992 Colorado Air Pollution Control and Prevention Act (Act), RFP reviewed the baseline air inventory and resubmitted APENs to the CDH, APCD. Based on the provisions of the revised State Act, updated APENs contained current air pollutant emissions data and operational information. In December 1992, 116 APEN Update Forms for sources of criteria pollutants were submitted to the CDH, APCD. Sources of hazardous pollutants will be addressed before December 1993.

During 1992, RFP submitted 42 permit applications for significant sources of oxides of nitrogen (NO_X) to the CDH, APCD, in order to limit NO_X emissions to permitted levels and maintain RFP in a minor source category for criteria pollutants. Permit applications were submitted for the Building 443 Steam Plant boilers, 32 emergency generators, and 9 internal combustion diesel engines.

Title VI of the Clean Air Act (CAA), "Stratospheric Ozone Protection," requires the phase-out of production of Class I ozone-depleting substances (ODSs) by the year 2000. In February 1992, this phase-out deadline was accelerated to December 31, 1993. Many new regulations concerning the use of ODSs are being promulgated at the state and federal level to implement other requirements of Title VI. Colorado Air Quality Control Commission Regulation No. 15, "Regulation to

Control Emissions of Ozone Depleting Compounds," is scheduled to become effective on January 30, 1993. This regulation requires refrigerant reclaiming and recycling, preventive maintenance plans, semiannual inspections, equipment registration, refrigerant tracking, annual reporting, and registration of personnel handling refrigerants. To help assess the full impact that these regulations will have on RFP operations and personnel, a comprehensive sitewide inventory of all refrigerant-using equipment is currently underway. When completed, the inventory will allow the Air Quality Division to determine which pieces of equipment on plantsite require registration and tracking based on the new regulations. RFP is continuing to purchase additional refrigerant reclaim systems and portable recovery units, proceeding with refrigerant equipment upgrades, retrofits, replacements, tracking mobile sources, and completing required reports. Two reports, *Ozone-Depleting Substances Phase-Out Plan* (EG92d) and *Review of Specifications and Requirements for Ozone-Depleting Substance Usage* (EG92g), were completed for submittal to DOE Rocky Flats Officer (RFO) and DOE Headquarters (HQ) during October and November 1992, respectively.

Clean Water Act (CWA)

The National Pollutant Discharge Elimination System (NPDES) permit program controls the release of pollutants into United States waters and requires routine monitoring of point source discharges and reporting of results. No Notices of Violation (NOVs) were received by RFP in 1992 for violation of NPDES standards. One exceedance (low pH at the Waste Water Treatment Plant [WWTP]) was reported by RFP on July 5, 1992. The cause was determined to be low flow; action was taken immediately to correct the condition, which has not reoccurred.

The Spill Prevention Control and Countermeasures/ Best Management Practices Plan (SPCC/ BMP) is a compilation of existing facility improvements, operational procedures, policies, and requirements for control of hazardous substances and spills. The current SPCC/BMP was completed in September 1992. An NPDES storm-water permit application was submitted in 1992 on schedule.

In October 1992, the Colorado Water Quality Control Commission (CWQCC) heard a petition by the DOE to reconsider the standards placed on Segment 5 of Big Dry Creek (tributaries from source to Ponds A-4, B-5, and C-2). The standards are based on the designated use, or classification, of a water body segment. Segment 5 was subject to stream standards with goal qualifiers. During the October meeting, DOE and EG&G Rocky Flats requested an extension of the goal qualifiers and temporary modifications and asked the CWQCC to revise the site-specific organic standards to achieve consistency with the statewide numeric standards for organic chemicals. In December 1992, the CWQCC rejected the proposal to continue the narrative ambient modifiers for 3 additional years and instead agreed to impose Segment 4 standards with temporary modifications for nine parameters.

Toxic Substances Control Act (TSCA)

In 1992, 89 drums of radioactive asbestos were shipped offsite. These drums consisted of low-level radioactively contaminated asbestos generated at several locations throughout RFP. One shipment of polychlorinated biphenyls (PCB) contaminated material also was prepared for shipment offsite in early 1993. RFP continues to store radioactively contaminated PCB waste beyond the 1-year storage limit imposed by Toxic Substance Control Act (TSCA) regulations. DOE has notified the EPA, Region VIII, that storage will be necessary until a commercial or DOE treatment and disposal facility capable of receiving this waste is identified.

Resource Conservation and Recovery Act (RCRA)

On June 17, 1992, EG&G Rocky Flats received an NOV under the Colorado Hazardous Waste Act. The State of Colorado, under authority of the EPA, regulates hazardous waste and the hazardous components of radioactive mixed waste at RFP. The NOV addressed 56 issues raised by the CDH, Hazardous Materials and Waste Management Division, during a 22-month period from July 1990 to June 1992. None of the findings involved offsite releases. In response to the NOV, EG&G developed more than 100 individual corrective actions tasks to address the findings.

During 1992, the RCRA Part A permit application was revised seven times to request changes to interim status and to support Part B permit modification requests.

Seven requests for modification to the Rocky Flats Plant RCRA Part B Operating Permit were submitted to CDH in 1992. In addition, a permit application supplement was submitted to EPA in February 1992 to address the requirements of the organic air emissions regulations, effective December 1990, and codified in 40 CFR 264 and 265, subparts AA and BB.

The Inter-Agency Agreement (IAG) requires RCRA Facility Investigations/Remedial Investigations (RFI/RI) work plans as a function of characterizing the source of the contamination and the soils of an interim status closure unit. RFI/RI work plans for the Solar Evaporation Ponds, Original Process Waste Lines, West Spray Field, and other Outside Closures received conditional approval during 1992. Quarterly groundwater monitoring also continued in 1992 for wells within three RCRA-regulated units scheduled for Interim Status Closure.

RCRA Contingency Plan was implemented on 23 occasions during 1992. Of the 23 occurrences that resulted in RCRA Contingency Plan implementation, six occurrences resulted from a lack of adequate secondary containment, and nine resulted from a waste being discovered in secondary containment, but not removed within 24 hours as required by RCRA regulations. The remaining eight occurrences were the result of various spills and releases.

National Response Center (NRC) Notifications

In 1992, per the requirements of 40 CFR 302.6, RFP notified the National Response Center of 32 releases to the environment of a hazardous substance that equaled or exceeded the reportable quantity. Twenty-nine of those releases involved small quantities (less than 10 gallons) of ethylene glycol/waste mixtures. The three remaining notifications involved one release of 28 pounds of asbestos in 40 pounds of insulation and two releases of contaminated groundwater that contained detectable levels of hazardous waste constituents. No notifications were made to the Local Emergency Planning Committees (LEPC) or State Emergency Response Commission (SERC) because exposure was limited to persons within the boundaries of the plant.

Waste Minimization

Significant gains were achieved during 1992 in efforts to reduce generation of radioactive and nonradioactive

hazardous wastes. Total radioactive waste generation in 1992 was 1,142 cubic meters (m^3), down from 2,042 m^3 in 1991. Transuranic (TRU) waste generation during 1992 was 10.01 m^3, while TRU mixed waste generation was 12.45 m^3. Totals of 678.71 m^3 of low-level and 440.39 m^3 of low-level mixed waste were generated during the year. Nonradioactive hazardous waste generation was reduced by 44 percent, from 39,042 kilograms in 1991 to 21,786 kilograms in 1992. TSCA-regulated waste decreased from 21,159 kilograms in 1991 to 1,506 kilograms in 1992, representing a 93 percent reduction. Paper recycling increased 67 percent during 1992 to a total of 348.5 tons. In addition, 14.3 tons of cardboard were recycled.

Compliance Issues

On November 3, 1989, the DOE, CDH, and EPA signed a Settlement Agreement and Compliance Order on Consent No. 89-10-30-01 regarding alleged violations of the RCRA hazardous waste regulations pertaining to proper waste management of residues. RFP submitted a series of documents in compliance with the Order, including the Mixed Residues Compliance Plan submitted September 28, 1990. On July 31, 1991, the CDH issued to RFP Compliance Order No. 91-07-31-01, which indicated that the Mixed Residues Compliance Plan was inadequate and therefore violated the November 1989 Order. In August 1991, the CDH filed a complaint in court alleging that DOE had submitted an inadequate plan in violation of the November 1989 Order. Compliance Order No. 91-07-31-01 specified a schedule for removing all backlog mixed residues from RFP by January 1, 1999, and a schedule by which mixed residues would be brought into physical and administrative compliance with the Colorado Hazardous Waste Regulations.

In order to meet the court-ordered deadline for obtaining a permit for all mixed residues currently stored at RFP, a Permit Modification request was submitted to the CDH on June 30, 1992. Work to upgrade mixed residue units to meet conditions of the Permit Modification was initiated and continued through 1992. In addition, the Permit Modification included a compliance schedule for submitting closure plans for out-of-service mixed residue units. Closure plans were submitted for out-of-service tank systems in Buildings 371 and 771 on September 11, 1992, and December 13, 1992, respectively.

Negotiations to resolve CDH's August 1991 suit continued throughout 1992. As part of these negotiations, a Mixed Residue Reduction Report was submitted on February 28, 1992, and a Mixed Residue Tank Systems Management Plan was submitted on March 31, 1992. The Tank Systems Management Plan, which was updated in August 1992, included schedules to bring mixed residue tank systems into compliance with the Colorado Hazardous Waste Regulations. The Mixed Residue Reduction Report, which was updated in November 1992, included preliminary plans for removing the inventory of mixed residues from RFP.

Federal Facilities Compliance Agreement (FFCA) II (an expansion of the original FFCA signed in 1989) was signed by the EPA and DOE on May 10, 1991, to provide a 24-month period for DOE to demonstrate achievements toward compliance with the Land Disposal Restrictions (LDR) portions of the Hazardous and Solid Waste Amendments (HSWA) of 1984 and the Colorado state laws applicable to RFP. During 1992, a variety of reports and plans were prepared and submitted to meet the requirements of the FFCA II. These reports and plans outline the development and implementation of various treatment technologies required to treat mixed wastes before disposal at offsite locations.

Inter-Agency Agreement (IAG)

The IAG for environmental restoration activities at RFP was signed on January 22, 1991, by DOE, EPA, and CDH. The agreement clarified the responsibilities and authorities of the three agencies related to environmental restoration, standardized requirements, described the procedures to be followed, and helped ensure compliance with orders and permits. Section 4, "Environmental Remediation Programs," describes remediation activities accomplished during 1992.

Emergency Planning and Community-Right-Know Act (EPCRA)

During 1992, there were no releases of extremely hazardous substances or CERCLA hazardous substances that posed a potential impact beyond RFP boundaries and required notification to the SERC and LEPCs.

RFP submitted the "Tier II Emergency and Hazardous Chemical Inventory Forms" report to emergency planning agencies for the State of Colorado, Jefferson and Boulder counties, and the RFP Fire Department in 1992. The report is required under Section 312 of

EPCRA and lists quantities and locations of hazardous chemicals. The RFP also submitted the "Toxic Chemical Release Inventory" (Form Rs) to the EPA and the State of Colorado in 1992 as required under Section 313 of EPCRA. This report contains information on quantities of routine and accidental releases of chemicals, the maximum amount of chemicals stored, and the amount of chemicals contained in wastes transferred offsite.

Agreement in Principle (AIP)

An AIP was executed between the DOE and CDH in 1989. Part of that agreement provided for CDH to conduct the Rocky Flats Toxicologic Review and Dose Reconstruction Study (CDH92), intended to examine chemical and radionuclide emissions from RFP and assess what health impacts, if any, may have occurred to the public. Phase I of the study, the final draft report of the Reconstruction of Historical Rocky Flats Operations & Identification of Release Points, was issued in August 1992. This is being followed by Phase II of the study, which will provide estimates of exposure risks. Completion of Phase II is expected in late 1993.

Special Assignment Team

On June 6, 1989, DOE mobilized a Special Assignment Team (Tiger Team) to provide an independent audit of operations and practices at RFP. The environmental portion of the audit focused on determining whether RFP activities created an imminent threat to the public or environment, whether operations were conducted in accordance with environmental requirements and best management practices, and the status of previously identified environmental concerns. Results of the original Tiger Team audit were reported in the *Assessment of Environmental Conditions at the Rocky Flats Plant* (DOE89). EG&G Rocky Flats responded to the findings in a document that outlined 93 separate action plans containing descriptions of measures to be taken to address the findings, including schedules, milestones, associated costs, and responsible parties. As of December 1992, 37 action plans were verified as complete, 33 plans were in verification, and 23 plans were open.

METEOROLOGICAL MONITORING

The 1992 mean temperature of 48.8 °F was nearly 1 °F below normal. The annual temperature extremes ranged from a high of 91 °F on July 6 to a minimum of -4 °F on January 15. The 1992 peak wind gust of 86 mph

occurred on January 24. Precipitation during the year was more than 1 inch below normal, totaling 14.49 inches. The largest daily precipitation fell on August 24 with 1.97 inches of rain. The largest 15-minute rainfall of 0.28 inches was also recorded on this date. Monthly precipitation ranged from 3.37 inches in March to 0.00 inches in September.

AIR MONITORING

Effluent Air Monitoring

Plutonium and uranium discharges totaled 0.4013 microcurie (μCi) (1.48×10^4 Becquerel [Bq]) and 0.9376 μCi (3.47×10^4 Bq), respectively. The maximum sample concentration for plutonium was 0.0000×10^{-12} microcuries per milliliter (μCi/ml) and for uranium was 0.0041×10^{-12} μCi/ml. Americium discharges totaled 0.2457 μCi (9.09×10^3 Bq). The maximum concentration was 0.00125×10^{-12} μCi/ml. The total measured amount of tritium discharged during 1992 was 0.0038 Ci (1.41×10^8 Bq). The maximum tritium concentration was 117×10^{-12} μCi/ml (4.33 Bq/m^3). The total quantity of beryllium discharged from ventilation exhaust systems was 3.399 grams (g). The maximum concentration was 0.00066 micrograms per cubic meter ($\mu g/m^3$). Radionuclide releases did not exceed NESHAP limits based on computer modeling using the AIRDOS/PC computer code.

Nonradioactive Ambient Air Monitoring

The maximum total suspended particulate (TSP) value (24-hour sample) was 106.2 $\mu g/m^3$, and the annual geometric mean value was 47.6 $\mu g/m^3$. The maximum Particulate Matter-10 (PM-10) value (24-hour sample) was 47.3 $\mu g/m^3$, and the annual arithmetic mean was 14.7 $\mu g/m^3$. The annual geometric mean for TSP was 79 percent of the former TSP primary annual geometric mean standards. The annual arithmetic mean standards for the PM-10 was 29 percent of the primary annual arithmetic mean standard.

Radioactive Ambient Air Monitoring

Overall mean plutonium concentration for onsite samplers was 0.099×10^{-15} μCi/ml (3.66×10^{-6} Bq/m^3), which is 0.49 percent of the offsite Derived Concentration Guide (DCG) for plutonium in air. Overall mean plutonium concentration for perimeter samplers was 0.002×10^{-15} μCi/ml (5.5×10^{-8} Bq/m^3), which is 0.008 percent of the

offsite DCG for plutonium in air. Overall mean plutonium concentration for community samplers was 0.001 x 10^{-15} µCi/ml (3.7 x 10^{-8} Bq/m^3), or 0.006 percent of the offsite DCG for plutonium in air.

SURFACE-WATER MONITORING

Rocky Flats Plant Site Surface-Water Monitoring

Maximum volume-weighted average concentrations and percent of DCG for plutonium, uranium, americium, and tritium of sampled effluents from North and South Walnut Creeks and Woman Creek are listed below.

	Surface-Water Effluents Average Concentrations (x 10^{-9} µCi/ml)	Percent of DCG
Plutonium (Pond C-2)	0.025 ± 0.004	0.08
Uranium-233, -234 (Pond C-2)	0.88 ± 0.07	0.18
Uranium-238 (Pond C-2)	1.43 ± 0.10	0.24
Americium (Walnut Creek)	0.005 ± 0.001	0.02
Tritium (Pond A-4)	59 ± 11	0.0

Mean concentrations and percent of DCG for plutonium, uranium, americium, and tritium for samples of raw water taken from Ralston Reservoir and South Boulder Diversion Canal are listed below.

	Raw Water Supply Average Concentrations (x 10^{-9} µCi/ml)	Percent of DCG
Plutonium	-0.002 ± 0.003	-0.01
Uranium-233, -234	0.36 ± 0.20	0.07
Uranium-238	0.31 ± 0.16	0.05
Americium	0.003 ± 0.005	0.01
Tritium	55 ± 138	0.00

Community Surface-Water Monitoring

Maximum average reservoir/canal concentrations and percent of DCG for plutonium, uranium, americium, and tritium from samples of public water supplies from several surrounding reservoirs are listed below.

	Maximum Average Reservoir Concentrations ($\times 10^{-9}$ µCi/ml)	Percent of DCG
Plutonium (Dillon)	0.028 ± 0.005	0.09
Uranium-233, -234 (Ralston)	0.80 ± 0.09	0.16
Uranium-238 (Ralston)	0.93 ± 0.10	0.16
Americium (Dillon)	0.012 ± 0.006	0.04
Tritium (Dillon)	78 ± 87	0.00

Maximum average drinking water concentrations and percent of DCGs for plutonium, uranium, americium, and tritium from samples of drinking water from several surrounding communities are listed below.

	Maximum Average Drinking Water Concentrations ($\times 10^{-9}$ µCi/ml)	Percent of DCG
Plutonium (Broomfield)	0.003 ± 0.013	0.01
Uranium-233, -234 (Denver)	0.44 ± 0.54	0.09
Uranium-238 (Thornton)	0.31 ± 0.05	0.05
Americium (Golden)	0.016 ± 0.042	0.05
Tritium (Louisville)	46 ± 24	0.00

GROUNDWATER MONITORING

Shallow groundwater within OU 1 (881 Hillside) is contaminated with Volatile Organic Compounds (VOCs), inorganics (including some metals), and elevated levels of uranium (much of it naturally occurring). The contaminants of most concern are VOCs in the unconfined groundwater system within the boundaries of Individual Hazardous Substance Site (IHSS) 119.1 in the eastern portion of the OU. Concentrations of VOCs diminish downgradient of IHSS 119.1, becoming equal to or below detection limits within 200 feet of the area. Slightly elevated concentrations of inorganic constituents also were found in the eastern portion of OU 1, where analytes detected above background levels included total dissolved solids (TDS), metals (nickel, strontium, selenium, zinc, and copper), and uranium.

Groundwater in the upper hydrostratigraphic unit within OU 2 (903 Pad, Mound, and East Trenches Area) is contaminated with VOCs, inorganics, dissolved metals, and some radionuclides. The upper hydrostratigraphic unit is comprised of alluvial materials and shallow subcropping sandstones. Inorganics and dissolved metals commonly occurring above background levels include TDS, strontium, barium, copper, and nickel, and to a lesser extent, chromium, manganese, selenium, lead, zinc, and molybdenum. The majority of the radionuclide contamination is uranium-238. Plutonium and americium are also present in some groundwater samples. Contaminants of most concern are VOCs. Those detected include tetrachloroethene, trichloroethene, and carbon tetrachloride.

Contaminants detected within OU 4 (Solar Ponds) include nitrate/nitrite, TDS, fluoride, bicarbonate, sulfate, dissolved radionuclides, and several dissolved metals. Dissolved radionuclides detected in surficial wells downgradient and in the immediate vicinity of the Solar Ponds during 1992 included uranium-233, -234 (as high as 136.3 pCi/l), uranium-235, uranium-238 (92.0 pCi/l), and tritium. Total radionuclides detected in the uppermost aquifer include americium-241 (0.40 pCi/l) and plutonium-239, -240 (0.67 pCi/l). VOCs detected in surficial wells in the vicinity of the Solar Ponds include trichloroethene, tetrachloroethene, carbon tetrachloride, and chloroform.

The Present Landfill (OU 7) is undergoing groundwater monitoring to assess the level and extent of contamination in the uppermost aquifer beneath the unit. Within the confines of the Present Landfill, groundwater contamination is characterized by the detection of VOCs, radionuclides, and concentrations of metals and inorganic analytes higher than in upgradient wells. Dissolved radionuclides detected in 1992 include tritium (up to 1.629 pCi/l), strontium-89, -90 (1.597 pCi/l), uranium-233, -234 (19.74 pCi/l), uranium-235 (0.72 pCi/l), and uranium-238 (16.09 pCi/l). Total radionuclides detected include americium-241 (0.06 pCi/l) and plutonium-239, -240 (up to 0.44 pCi/l). Detection of VOCs occurred primarily in wells in the southern portion of the landfill. A number of different compounds were detected including carbon tetrachloride, trichloroethene, tetrachloroethene, and others.

Within and adjacent to the West Spray Field (OU 11), groundwater quality has been impacted by dissolved radionuclides, a few dissolved metals, and inorganic analytes. Dissolved radionuclides detected include uranium -233, -234 (at 1.39 pCi/l), and uranium-238 (0.83 pCi/l). Total radionuclides in the uppermost aquifer within the West Spray Field include americium-241 (0.088 pCi/l) and plutonium-239 (0.25 pCi/l). Inorganic analytes detected in the West Spray Field at concentrations above background include fluoride, chloride, bicarbonate, sodium, sulfate, nitrate/nitrite, orthophosphate, and total suspended solids.

SOIL MONITORING

Plutonium concentrations from soil samples taken at a 1-mile radius from RFP ranged from 0.03 picocuries per gram (pCi/g) to 11.0 pCi/g. Soils sampled at a 2-mile radius from RFP ranged from 0.01 pCi/g to 8.8 pCi/g. Soil samples taken east of the 903 Pad area exhibited the highest plutonium concentrations.

ECOLOGICAL STUDIES

Ecological studies are an ongoing part of RFP routine operations. These studies focus on the presence, abundance, and spatial distribution of plant and animal life at RFP and help identify the impacts of the plant relative to compliance with the NEPA, 40 CFR 1500-1508, 10 CFR 1021, and DOE Order 5440.1D, *National Environmental Policy Act Compliance Program.* Several ecological

studies continued during 1992, including Baseline Studies, Radioecological Investigations, and Environmental Evaluations (EEs).

ENVIRONMENTAL REMEDIATION (ER) PROGRAMS

Environmental Remediation (ER) Programs were established to comply with regulations for characterization and cleanup of inactive waste sites at RFP. The legal framework that establishes the scope and schedule for projects in the ER Program is the IAG. The IAG addresses details on specific response requirements that must be met during the CERCLA and RCRA processes used to assess and remediate identified IHSSs on or adjacent to RFP. These IHSSs have been categorized into 16 OUs. These OUs, along with activities that occurred during 1992, are detailed in Section 4, "Environmental Remediation Programs."

EXTERNAL GAMMA RADIATION DOSE MONITORING

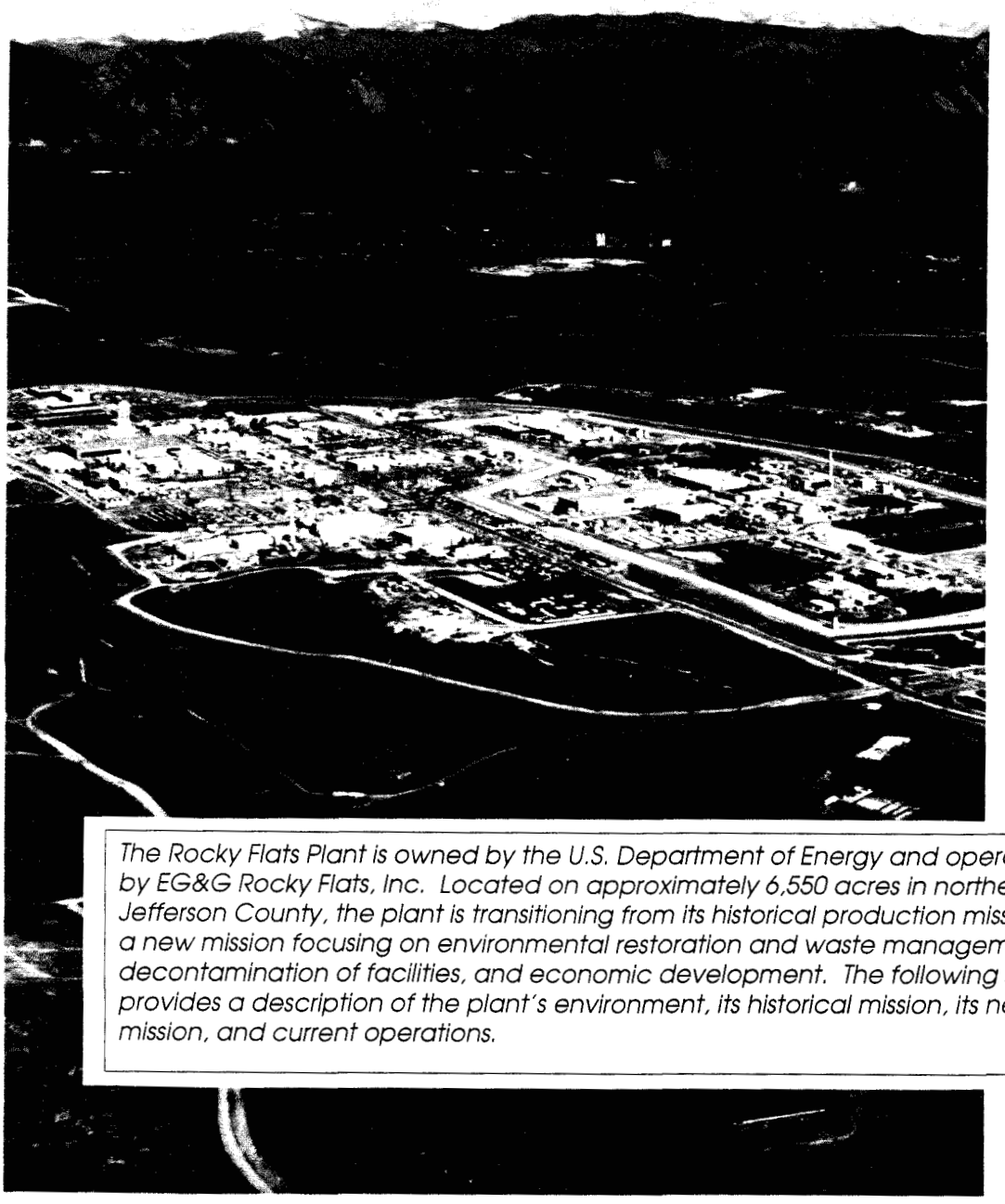
Average annual dose equivalents measured onsite, in the perimeter environment, and in nearby communities were 121, 105, and 120 millirem (mrem) (1.21, 1.05, and 1.20 milliSieverts [mSv]), respectively. These values are indicative of background gamma radiation in the area.

RADIATION DOSE ASSESSMENT

Maximum radiation dose from all pathways to a hypothetical individual continuously present at the site boundary was 0.46 mrem Effective Dose Equivalent (EDE). The maximum radiation dose to an individual from RFP air emissions of radioactive materials, as determined by the CAP88-PC meteorological dispersion/radiation dose computer code, was 2.8×10^{-5} mrem EDE from measured building air emissions and 1.7×10^{-3} mrem EDE from estimated soil resuspension. Collective population dose to a distance of 50 miles was estimated as 0.1 person-rem EDE. These doses are in accordance with the DOE objective that potential exposures to members of the public be as low as reasonably achievable (ALARA).

1. Introduction

Patrick J. Etchart



The Rocky Flats Plant is owned by the U.S. Department of Energy and operated by EG&G Rocky Flats, Inc. Located on approximately 6,550 acres in northern Jefferson County, the plant is transitioning from its historical production mission to a new mission focusing on environmental restoration and waste management, decontamination of facilities, and economic development. The following section provides a description of the plant's environment, its historical mission, its new mission, and current operations.

ROCKY FLATS SITE ENVIRONMENT

The Rocky Flats Plant (RFP), owned by the U.S. Department of Energy (DOE) and operated by EG&G Rocky Flats, Inc., is located on approximately 6,550 acres in northern Jefferson County. The facility is approximately 16 miles northwest of downtown Denver (Figure 1-1). Primary facilities are located on approximately 384 acres near the center of the RFP plantsite within a fenced security area. The remaining plant area contains limited support facilities and serves as a buffer zone to major production areas (DOE80). (NOTE: Literature citations abbreviated within this report are alphabetically listed in Section 8, "References.")

Approximately 2.1 million people live within a 50-mile radius of RFP. Adjacent land use is a mixture of agriculture, open space, industry, and low-density residential housing.

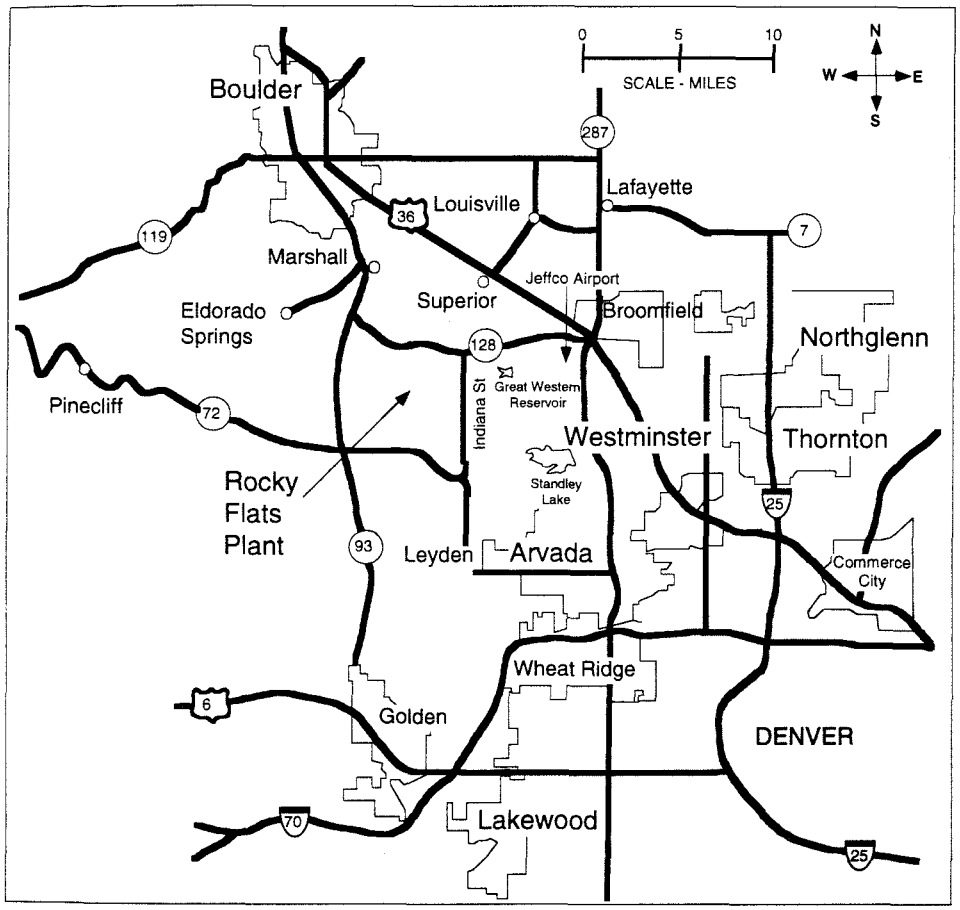


Figure 1-1. Area Map of RFP and Surrounding Communities

Climate

The climate at RFP is temperate and semiarid, characteristic of Colorado's Front Range. Elevation and major topographical features significantly influence climate and meteorological dispersion characteristics of the RFP site. Winds, although variable, are predominately northwesterly. Annual precipitation is nearly 16 inches with more than 40 percent occurring from April through June. Maximum and minimum temperatures average 76 degrees Fahrenheit (°F) and 22 °F, respectively (DOE80). Meteorological and climatological information for 1992 is provided in Section 3.1.

Topography

Located at an elevation of approximately 6,000 feet, the RFP is on the eastern edge of a geological bench known locally as Rocky Flats. This bench, approximately 5 miles wide in an east-west direction, flanks the eastern edge of the abruptly rising foothills of the Front Range of the Rocky Mountains. To the east, topography slopes gradually at an average downgrade of 95 feet per mile. Approximately 20 miles to the west, the continental divide rises to elevations exceeding 14,000 feet.

Geology

RFP is situated on the Rocky Flats Alluvium, an alluvial fan deposit, varying in thickness from approximately 103 feet to less than 10 feet and providing a gravelly cover over bedrock. Underlying bedrock formations consist primarily of claystone with some siltstones. Seismic activity of the area is low, and the potentials for landslides and subsidence are not likely at RFP (DOE80). Additional information on the geology of RFP is contained in the *Geologic Characterization of the Rocky Flats Plant* (EG91f).

Hydrology

Surface drainage generally occurs in a west to east pattern along five short-lived streams within RFP. North Walnut Creek, South Walnut Creek, and Woman Creek drain the main plant facilities area. The other two drainages are Rock Creek and an unnamed tributary that flows into Walnut Creek. Water from Woman Creek drains into Standley Lake, which is used as a municipal water supply. Surface runoff from RFP is collected in an interceptor ditch before it enters Woman Creek, diverted to a temporary holding pond, and piped into the Broomfield Diversion Ditch, which bypasses Great Western Reservoir, a water supply for the City of Broomfield. Water from North Walnut Creek and South Walnut Creek discharges into the Broomfield Diversion Ditch.

Groundwater systems consist of a shallow, unconfined system in the Rocky Flats Alluvium and a confined system in deeper sandstone units within the underlying bedrock. The flow of groundwater is locally controlled by the topography and subcropping sandstone channels (refer to Figure 3.4-1, Generalized Cross Section of the Stratigraphy Underlying the RFP).

ROCKY FLATS SITE OPERATIONS

The United States Atomic Energy Commission (AEC), the early predecessor to the DOE, originally announced plans to construct the RFP in 1951. Construction of the facility began in 1952, and the first components were completed and shipped offsite in 1953. The primary mission of the facility was to produce components for nuclear weapons from materials such as plutonium, uranium, beryllium, and various alloys of stainless steel. Additional plant missions included plutonium recovery and reprocessing, and waste management. Production activities included metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions.

The original plantsite represented a total area of 2,520 acres, with the early buildings constructed within a controlled area of less than 400 acres. Approximately 700,000 square feet (ft^2) of building floor space was available in 20 structures. Through the years, the plant's environmental buffer zone was enlarged, and additional structures were built. Today, approximately 140 structures contain nearly 2.76 million ft^2 of floor space. Of this space, major manufacturing, chemical processing, plutonium recovery, and waste treatment facilities occupy approximately 1.6 million ft^2.

RFP is a government-owned, contractor-operated facility. The AEC was the responsible government agency at RFP until 1974, when the United States Energy Research and Development Administration (ERDA) succeeded the AEC. The ERDA, in turn, was succeeded by the DOE in 1977. Within DOE, administrative responsibility for RFP historically was delegated to the Albuquerque Operations Office, which established the Rocky Flats Area Office (RFAO) for day-to-day contact at RFP. In 1989, the RFAO was upgraded to the Rocky Flats Office (RFO), reporting directly to DOE Headquarters (HQ) in Washington, D.C.

The Dow Chemical Company was the first prime contractor for operations at RFP. Rockwell International replaced the Dow Chemical Company in 1975 and operated RFP through 1989. EG&G Rocky Flats, Inc., replaced Rockwell International in 1990. EG&G Rocky Flats employed 6,828 people in December 1992.

The plant's historical production mission was officially discontinued in 1992 with the end of the Cold War and the administration's decision not to resume weapons component production activities at RFP. EG&G formed a Transition Management organization to help RFP transition to a new mission focusing on environmental restoration, waste management, decontamination and decommissioning (D&D) of facilities, and economic development. The focus of the transition process during 1992 was the development of the *Rocky Flats Plant Mission Transition Program Management Plan*. The plan describes a strategy and outlines schedules for preparing facilities for cleanup, deactivation, decontamination, and alternate uses. Waste and environmental facilities at the plant will continue to operate in support of transition efforts, including decontamination of facilities. Consolidation of special nuclear material, classified documents, and other sensitive material into fewer, more centralized locations on plantsite is an important element of the plan.

RADIATION AT THE ROCKY FLATS PLANT

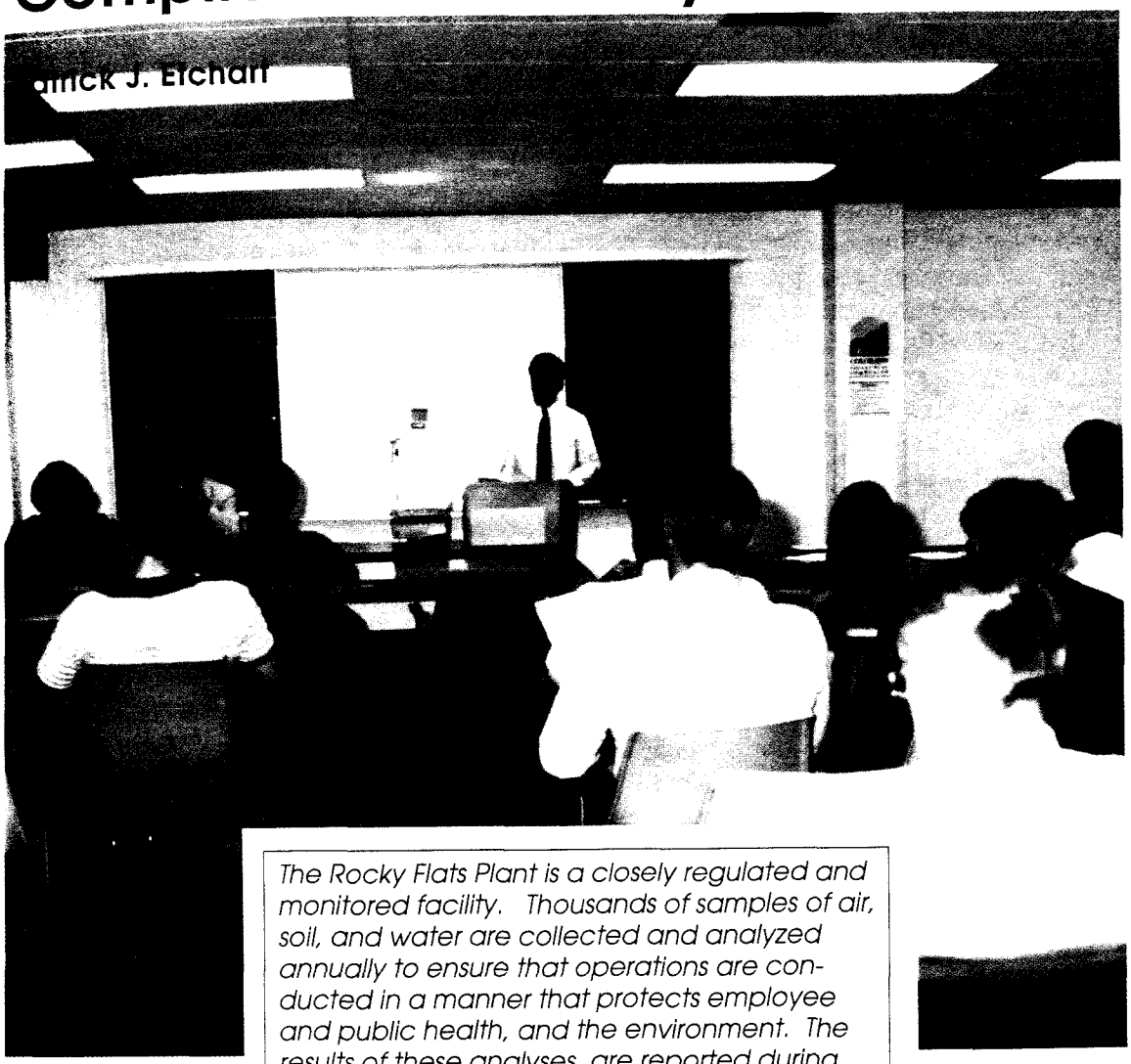
Radioactive materials and radiation-producing equipment are managed at the RFP. Radiation-producing equipment includes X-ray machines and linear accelerators. Primary radioactive materials include plutonium, americium, uranium, and tritium. Many of these materials will continue to be handled at RFP as the plant proceeds with decontamination of facilities and consolidation of materials for safe storage and eventual transfer offsite. The potential exists for these materials to be handled in sufficient quantities during the transition process to pose an offsite hazard. The most important potential contributor to radiation dose from these materials is alpha radiation emitted by plutonium, americium, and uranium.

Because of the low penetrating ability of alpha radiation, these materials are a potential internal radiation dose hazard; that is, the radioactive material must be taken into the body for the alpha radiation to be harmful. For this reason, environmental protection at RFP

focuses on minimizing release of radioactive materials to the environment. Environmental monitoring focuses on pathways by which the materials could enter the body, such as air inhalation and water ingestion. A pathway is a potential route for exposure to radioactive or hazardous materials.

Appendix A, "Perspective on Radiation," describes the basic concepts of radiation. Readers unfamiliar with the types and sources of ionizing radiation are encouraged to read Appendix A for a better understanding of environmental monitoring data and radiation dose assessment at RFP. A detailed assessment of radiation dose to the public from RFP is presented in Section 6, "Radiation Dose Assessment."

2. Compliance Summary



The Rocky Flats Plant is a closely regulated and monitored facility. Thousands of samples of air, soil, and water are collected and analyzed annually to ensure that operations are conducted in a manner that protects employee and public health, and the environment. The results of these analyses are reported during monthly public meetings and to various local, state, and federal regulatory authorities. This section is designed to summarize compliance activities related to environmental statutes, regulations, orders, and agreements.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

The National Environmental Policy Act (NEPA) is the nation's most widely applied federal environmental statute. Federal regulations administered by the Council on Environmental Quality (CEQ), Washington, D.C., require NEPA documentation as an administrative record showing that federal agencies have considered environmental impacts of and public commentary on proposed actions, and that this information is included in federal decision-making. NEPA documentation can include either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS).

The RFP established a NEPA Compliance Committee (NCC) in February 1989 to provide an integrated review, guidance, and oversight function for plantwide activities. The NCC created an RFP Environmental Checklist (EC) that is required for all proposed actions. The EC provides an initial screening and review of construction and engineering projects to determine whether submission of an Action Description Memorandum (ADM) is required. ADMs are submitted to DOE for a determination of the level of NEPA documentation required. Guidance has been received from DOE regarding NEPA. Such guidance comes from documents such as *Code of Federal Regulations* 10 CFR 1021 and DOE Order 5440.1E.

In 1992, the NCC provided information and recommendations on approximately 120 projects related to construction, refurbishment, or upgrades of RFP facilities.

Environmental Assessment (EA)

An Environmental Assessment (EA) is prepared to determine whether a proposed federal action will require preparation of an EIS. If it is determined that no EIS is required, a Finding of No Significant Impact (FONSI) that documents this decision is prepared. Before preparation of an EA, the proposed federal action is evaluated as a possible Categorical Exclusion (CX). The CX is a category of actions that do not individually or cumulatively have a significant effect on the human environment and do not require either an EA or an EIS. Twenty CXs were approved for RFP in 1992.

EAs for the following proposed actions are in various stages of preparation and review.

- New Sanitary Landfill
- Surface Water Structures Maintenance

Mitigation Action Plan (MAP)

The implementation of NEPA focuses on the predecisional aspects of an action. Mitigation is part of the postdecisional phase of NEPA. "NEPA Implementing Procedures and Guidance," 10 CFR 1021, requires the publication of a Mitigation Action Plan (MAP) for EAs and EISs that include mitigation commitments before the EA/FONSI is completed and after the EIS/Record of Decision (ROD) has been issued. The MAP documents environmental commitments made in an EIS/ROD or an EA/FONSI and reports implementation of those commitments.

An EA for the Supercompactor and Repackaging Facility (SARF), DOE/EA-0432, was originally published in July 1990. The DOE issued a FONSI in the Federal Register in August 1990, and the MAP for the SARF was approved in January 1992.

ENDANGERED SPECIES ACT, FISH AND WILDLIFE COORDINATION ACT, MIGRATORY BIRD TREATY ACT, COLORADO NONGAME, THREATENED AND ENDANGERED SPECIES CONSERVATION ACT, AND 10 CFR 1022 (PROTECTION OF WETLANDS AND FLOODPLAINS)

Various federal statutes and executive orders govern the protection of ecological/biological resources at RFP. In 1992, several Public Notices of Wetland/Floodplain Involvement and Statements of Findings were published in the Federal Register as required by 10 CFR 1022. These notices and statements of findings are provided below.

- Sitewide Treatability Study at the RFP
  - Notice of Involvement - March 30, 1992
  - Statement of Findings - October 2, 1992

- Well Plugging and Abandonment Program at the RFP
  - Notice of Involvement - April 2, 1992
  - Statement of Findings - October 20, 1992

- Site Characterization Activities at Operable Units 1, 2, 5, and 6 at the RFP
  - Notice of Involvement - April 21, 1992
  - Statement of Findings - October 2, 1992

- Proposed Resource Conservation and Recovery Act and Comprehensive Environmental Response, Compensation, and Liability Act Characterization and Remediation Studies in Operable Units 3, 4, 7, and 9 at the RFP

- Notice of Involvement - May 8, 1992
- Statement of Findings - October 2, 1992

- Surface Water Monitoring Station Upgrades and Installations at the RFP
  - Notice of Involvement - May 8, 1992
  - Statement of Findings - October 20, 1992

Two 3-year surveys were initiated in 1992 for the Ute Ladies'-Tresses orchid, a threatened species, and the Preble's Jumping Mouse, which is listed as a Category 2 species. Category 2 indicates that the Preble's Jumping Mouse is presently neither threatened nor endangered, but is under consideration for threatened status. A permit to trap the Preble's Jumping Mouse was obtained from the Colorado Division of Wildlife to facilitate the survey. A survey on migratory birds also was conducted.

NATIONAL HISTORIC PRESERVATION ACT (NHPA)

Preservation and management of prehistoric, historic, and cultural resources on lands administered by the DOE are mandated under Sections 106 and 110 of the National Historic Preservation Act (NHPA). The NHPA requires a federal agency, before undertaking any project, to adopt measures to mitigate the potential adverse effects of that project on sites, structures, or objects eligible for inclusion in the National Register of Historic Places.

A sitewide archaeological survey at RFP was originally conducted in 1991. This survey evaluated all cultural resources against criteria for nomination to the National Register of Historic Places. Survey results were reported in "Cultural Resources Class III Survey of Department of Energy, Rocky Flats Plant, Northern Jefferson and Boulder Counties, Colorado" (Version 1.0, August 1, 1991). Although no new archaeological data was generated during 1992, information from the report continues to be used in planning remediation and other construction activities to prevent damage to, or destruction of, cultural resources at RFP.

CLEAN AIR ACT (CAA)

The Clean Air Act (CAA) sets standards for ambient air quality and for air emissions of hazardous air pollutants. The federal regulatory agency of authority is the EPA. Under the CAA, states may administer and

enforce CAA provisions by obtaining EPA approval of a State Implementation Plan (SIP). Colorado has been granted such CAA primacy by the EPA for air pollutants other than radioactive materials. The 1992 Colorado Air Pollution Prevention and Control Act (formerly the Colorado Air Quality Control Act) establishes Colorado's program of air pollution control, with implementing regulations promulgated by the Colorado Air Quality Control Commission (CAQCC). Consequently, appropriate compliance programs have been established at RFP for radioactive and nonradioactive hazardous emissions and ambient air conditions.

National Emission Standards for Hazardous Air Pollutants (NESHAPs)

National Emission Standards for Hazardous Air Pollutants (NESHAPs) govern radioactive and other hazardous air pollutants and are administered by the EPA or the CDH. CDH has been granted authority by the EPA to regulate several hazardous pollutants including beryllium, mercury, vinyl chloride, and asbestos. Authority to regulate radionuclides remains with the EPA. Under regulations promulgated in 1989, NESHAPs limited the radiation dose to the public from airborne radionuclide emissions from DOE facilities to 10 millirem per year (mrem/yr) effective dose equivalent (EDE). A compliance report with dose calculations is due to EPA by June 30 of each year for the previous calendar year. The 1991 report showed an EDE to the public of 0.00934 mrem from building and diffuse emissions. Preliminary 1992 data indicate an EDE of 0.0017 mrem from the same sources. Dose calculations for the 1992 calendar year are provided in Section 6, "Radiation Dose Assessment."

The 1989 revision to the radionuclide NESHAPs stipulated specific monitoring protocol to be used in determining radionuclide air emissions. The new monitoring protocol created a noncompliance at RFP because the existing sampling systems were designed and installed years before the EPA issued any guidance. As a result, EPA issued EG&G Rocky Flats an Administrative Compliance Order (ACO) on March 3, 1992, mandating compliance with monitoring requirements by March 15, 1993. EG&G conducted several air quality studies and projects to assess and achieve compliance. Duct assessment reports (DARs), containing information from the studies and projects, were submitted to EPA on December 18, 1992, for review and approval. The DARs show that 61 of 63

radionuclide sampling systems meet the protocol. Alternative sampling methodology approval was requested for two of the locations and was later received for one location. EPA Region VIII has not been able to determine whether the monitoring procedures for the balance of the locations are acceptable and has therefore deferred the review and final determination to EPA headquarters.

CAQCC Regulation No. 8

Regulation No. 8 implements NESHAPs for nonradioactive hazardous air pollutants in Colorado. Work standards, emission limitations, and ambient air standards for hazardous air pollutants including asbestos, beryllium, mercury, benzene, vinyl chloride, lead, and hydrogen sulfide are specified in this regulation. Potential hazardous air pollutants at RFP include asbestos and beryllium. Asbestos was used as insulation in older facilities and is handled according to NESHAPs regulations during demolition, renovation, or disposal. Beryllium is machined at RFP. The emissions standard is 10 grams (g) of beryllium over a 24-hour period. Beryllium emissions did not exceed this standard in 1992 (see Section 3.2, "Air Monitoring").

Beryllium compliance tests were to be conducted on five air effluent ducts that had the highest potential beryllium emissions in 1991 upon resumption of plutonium operations at RFP. The tests were to measure beryllium emissions from each of the five locations over a 24-hour period in accordance with EPA Reference Method 104 and serve as the basis of an application for a waiver of emission testing and sampling protocol. Plutonium production operations were suspended in 1989 and are not expected to resume because of the change in the plant mission. The change in mission may curtail beryllium operations at RFP and render compliance testing unnecessary.

CAQCC Regulation No. 3

Air Pollutant Emission Notice (APEN) - Enforcement, maintenance, and implementation of air regulations concerning nonradionuclide air pollutant emissions have been delegated by the state to the CDH, Air Pollution Control Division (APCD). Under the provisions of Regulation No. 3, the CDH must receive an APEN for any existing or new source of air pollutants resulting from construction or alteration of any facility, process, or activity from which regulated air pollutants

are emitted. APENs provide (1) source-specific data, (2) an estimate of the quantity and composition of the air emissions generated from source operations, and (3) supporting information for Colorado Air Permit regulations. When viewed as a related body of information, APENs make up the RFP nonradionuclide air emission inventory and reflect the dynamics of plant operations.

Approximately 240 APENs were filed with the state during the last 3 years, including the baseline air emission inventory completed in June 1991. Under the June 1989 Agreement in Principle (AIP) between the DOE and the CDH, RFP was required to complete a baseline air emission inventory of plant operations and submit inventory data to the CDH by June 1991. Between June 1989 and June 1991, RFP conducted an air emission survey of plant activities, evaluated process operations, and prepared APENs and supporting building/process documentation for submittal to the CDH. Since the completion of this initial effort, the Air Quality Division (AQD) has provided additional APENs for new or modified plant operations.

Colorado Senate Bill 105, signed into law in June 1992, amended the Colorado Air Quality Control Act to comply with and implement the Federal CAA Amendments of 1990. One of the new provisions of the revised state Act is the requirement for all existing sources within the state to file updated APENs with current operational information. Additionally, the provisions of the Act contain both new APEN reporting thresholds and expanded reporting requirements. The regulatory due date for updated APENs for sources of criteria pollutants was December 31, 1992; sources of hazardous pollutants are deferred until December 31, 1993.

In response to this new requirement, 116 APEN Update forms for criteria pollutants and 46 supporting APEN Reports were submitted to the APCD on December 23, 1992. A list of the buildings and operations for which APEN Reports were submitted in 1992 is provided in Table 2-1.

Table 2-1

Buildings for Which Air Pollutant Emission Notices Were Submitted or Resubmitted in 1992

Building Reference Number(s)	Building/Operation Description	Date Submitted To CDH
120 (Revision 2)	Emergency Generator	12/04/92
121	Security Documents /Incinerator	12/04/92
123 (Revision 2)	Health Physics	12/04/92
123S (Revision 2)	Hazardous Waste Storage Shed Hot Water Heaters	12/04/92
124 (Revision 2)	Emergency Generator	12/04/92
127 (Revision 1)	Emergency Generator	12/04/92
207A-C (Revision 3)	Solar Pond	12/04/92
219 (Revision 1)	Landfill	12/04/92
D262 (Revision 2)	Diesel Fuel Storage Tank	12/04/92
228A (Revision 1)	Drying Beds (910)	12/04/92
228B (Revision 1)	Drying Beds (910)	12/04/92
331 (Revision 1)	Garage & Fire Station	12/04/92
333 (Revision 1)	Paint Shop & Sand Blast Facility	12/04/92
334 (Revision 1)	General Shop (Maintenance)	12/04/92
371 (Revision 2)	Plutonium Recovery, Waste Treatment	12/04/92
372A (Revision 2)	Emergency Generator	12/04/92
373 (Revision 2)	Cooling Tower (374)	12/04/92
374 (Revision 2)	Process Waste Treatment Facility	12/04/92
427 (Revision 1)	Emergency Generator Building (444)	12/04/92
439 (Revision 1)	Mod Center/Machine Shop	12/04/92
440 (Revision 1)	Modification Center	12/04/92
442 (Revision 1)	Filter Test Laboratory/Storage	12/04/92
443 (Revision 1)	Heating Plant	12/04/92
444 (Revision 1)	Multipurpose Manufacturing Facility	12/04/92
445 (Revision 1)	Management & Storage of Bulk from 444	12/04/92
447 (Revision 1)	Manufacturing & Waste Processing	12/04/92
448 (Revision 1)	Storage for 447	12/04/92
450 (Revision 1)	Exhaust Filter Plenum	12/04/92
451 (Revision 1)	Exhaust Filter Plenum	12/04/92
T452F (Revision 1)	Offices/Health Effects Lab	01/09/92
455 (Revision 1)	Exterior Exhaust Filter Plenum	12/04/92
460 (Revision 1)	Nonnuclear Manufacturing	12/04/92
549 (Revision 1)	Support Contractor Maintenance Shop/Cons.	12/04/92
556 (Revision 1)	Metal Cutting Building	12/04/92
559 (Revision 1)	Plutonium Analytical Laboratory	12/04/92
561 (Revision 1)	Exhaust Plenums for 559	12/04/92
562 (Revision 1)	Emergency Generator	12/04/92
566 (Revision 1)	Protective Clothing Decontamination	12/04/92
662 (Revision 2)	Emergency Generator	12/04/92
664 (Revision 1)	Radioactive Solid Waste Disposition Center	12/04/92
T690J (Revision 1)	Trailer - Laboratory	12/04/92
T690K (Revision 1)	Trailer - Laboratory	12/04/92
T690L (Revision 1)	Trailer - Laboratory	12/04/92
701 (Revision 1)	Maintenance Building	12/04/92
701-Furn. (Revision 1)	Bickley Furnace	12/04/92
701-MW (Revision 1)	Microwave Vitrification	12/04/92
705 (Revision 1)	Coating Laboratory	12/04/92
707 (Revision 1)	Plutonium Fabrication, Pyrochemical Ops.	12/04/92
T707S (Revision 1)	Oil Storage Shed	01/09/92
708 (Revision 1)	Compressor Building	12/04/92
708 (Revision 2)	Emergency Generator	12/04/92
709 (Revision 1)	Cooling Tower (707)	12/04/92
711 (Revision 1)	Cooling Tower (707)	12/04/92

Table 2-1 (continued)

Buildings for Which Air Pollutant Emission Notices Were Submitted or Resubmitted in 1992

Building Reference Number(s)	Building/Operation Description	Date Submitted To CDH
715 (Revision 1)	Emergency Generator	12/04/92
715A (Revision 1)	Emergency Generator	12/04/92
727 (Revision 1)	Emergency Generator	12/04/92
729 (Revision 1)	Exhaust Filter Plenum	12/04/92
729 (Revision 2)	Emergency Generator	12/04/92
762A (Revision 2)	Emergency Generator	12/04/92
771 (Revision 2)	Plutonium Recovery	12/04/92
774 (Revision 1)	Waste Treatment Plant	12/04/92
776 (Revision 1)	Manufacturing Building	12/04/92
777 (Revision 1)	Assembly Building	12/04/92
778 (Revision 1)	Service Building	12/04/92
779 (Revision 1)	R & D Facility	12/04/92
779 (Revision 2)	Emergency Generator	12/04/92
782 (Revision 1)	Exhaust Filter Plenum	12/04/92
792A (Revision 2)	Emergency Generator	12/04/92
827 (Revision 1)	Emergency Generator Building	12/04/92
865 (Revision 1)	Material & Process Development Lab.	12/04/92
867 (Revision 1)	Filter Plenum	12/04/92
868 (Revision 1)	Filter Plenum	12/04/92
881-891	Hillside Remediation	03/27/92
881 (Revision 1)	Research & General Support	12/04/92
881G (Revision 1)	Emergency Generator Building	12/04/92
889 (Revision 1)	Waste Packaging/Decontamination	06/19/92
891	Water Storage Tanks	01/20/92
T903A (Revision 1)	Field Station for Air Monitoring	12/04/92
910 (Revision 3)	Solar Pond - Evaporation Project	12/04/92
920 (Revision 2)	Emergency Generator	12/04/92
928 (Revision 1)	Elec. Fire Water Pump/Diesel Backup Pump	12/04/92
952 (Revision 1)	Gas Cylinder Storage	01/09/92
964 (Revision 1)	Storage of Solid Low Level Rad. Mixed Waste	01/09/92
980 (Revision 1)	Subcontractor Metal Shop	12/04/92
988 (Revision 1)	Sanitary Wastewater Treatment	12/04/92
989 (Revision 1)	Emergency Generator Building	12/04/92
990 (Revision 1)	Sanitary Wastewater Treatment	12/04/92
990A (Revision 1)	Sanitary Wastewater Treatment	12/04/92
991 (Revision 1)	Product Warehouse	12/04/92
995 (Revision 1)	Sewage Treatment Facility	12/04/92
RFP - Sitewide (Revision 1)	Natural Gas Combustion Units	12/04/92
RFP - Sitewide (Revision 2)	Natural Gas Hot Water Heater, Solar Pond Evap. Proj.	12/04/92
RFP - Sitewide (Revision 1)	Outside Industrial Storage Tanks	12/04/92
RFP - Sitewide (Revision 1)	Pondcrete Shelters	12/04/92
RFP - Sitewide	Propane Fuel Combustion Units	12/04/92
RFP - Sitewide (Revision 1)	Supercompactor-Transuranic Waste Shredder.	12/04/92
RFP (Revision 1)	Oxides of Nitrogen Emission Report (NOX)	07/17/92

Colorado Air Permits - Colorado Air Quality Regulation No. 3 mandates that all sources of regulated air pollutants obtain an air permit prior to construction, modification, or operation of any building or facility, or performance of any activity unless specifically exempted under the law. This regulation specifically exempts from permit requirements all sources in existence prior to February 1, 1972. Because most RFP production facilities and support operations were in existence prior to this date, Colorado air permits are not required for these activities. All other sources, however, are subject to compliance with the air permit regulations. At this time, RFP has 12 active or initial air permits and approximately 41 permit applications on file with the state. As part of the AQD's responsibilities, all qualified new or modified sources of regulated pollutants are evaluated against the regulatory permit requirements to determine qualification for an air permit application. Table 2-2 lists current air quality permits for RFP as well as surface water and hazardous waste permits and permit applications.

Operating Permit Program - The 1992 amendments to the Colorado Air Quality Control Act include provisions to comply with and implement all the CAA amendments of 1990 and incorporate them into the Colorado State Implementation Plan. As a result of the new statutes, Colorado will develop during 1993 an operating permit program based upon the federal regulations implementing Title V of the CAA Amendments (which establishes a federally enforceable, renewable operating permit program). Under the provisions of these new regulations, RFP will need to develop a facility operating permit that includes all emissions limitations and standards applicable to plant sources, record-keeping and reporting requirements, compliance schedules, and provisions to demonstrate that RFP is in compliance with all applicable requirements of the air regulations. This operating permit could be required by the state as early as November 1994.

Table 2-2

Environmental Permits and Permit Applications

Permit/Application	Number	Medium	Issuing Agency	Status
NPDES (12/26/84)	CO-0001333	Water	EPA	Application for revision pending
NPDES Storm Water (10/1/92)	CO-0001333	Water	EPA	Application submitted
Building 122 Incinerator (3/25/82)	C-12,931	Air	CDH	Active permit (inactive source)
Building 771 Incinerator (8/28/85)	12JE932	Air	CDH	Active permit (inactive source)
Building 776 Incinerator (3/25/82)	C-13,022	Air	CDH	Active permit (inactive source)
Fugitive Dust Renewed (12/6/91)	87JE084L	Air	CDH	Permit expires December 31, 1994
Pondcrete Shelter #5 Pad	90JE045	Air	CDH	Initial approval, permit issued August 21, 1991
Pondcrete Shelter #6 Pad	90JE045	Air	CDH	Initial approval, permit issued August 21,1991
Pondcrete Shelter #10 Pad	90JE045	Air	CDH	Initial approval, permit issued August 21, 1991
Pondcrete Shelter #11 Pad	90JE045	Air	CDH	Initial approval, permit issued
Urinalysis Laboratory Fume Hood Bldg. 123	86JE018	Air	CDH	Active permit
Building 776 Supercompactor and Repackaging Facility (SARF)/transuranic Waste Shredder-HEPA filter	91JE047	Air	CDH	Initial permit issued in December 1991
Building 333 paint spray booth and grit blaster	91JE300	Air	CDH	Initial permit issued July 31, 1992
Building 910 three forced evaporation units and one natural gas fired heater	91JE316	Air	CDH	Initial permit issued July 31, 1992
Building 995 natural gas fired sludge dryer	91JE430	Air	CDH	Initial permit issued July 31, 1992
Building 440 paint spray booths	91JE537	Air	CDH	Initial permit issued in November 1991
Building 373, Vent, Detroit diesel engine pump	92JE473	Air	CDH	Initial approval issued December 14, 1992. Initial permit will be issued when permit fees are paid.
RCRA Part A	CO-7890010526 latest revision	Hazardous, low-level mixed waste, transuranic mixed waste plus mixed residues	CDH	Part A applications for hazardous and low-level mixed waste and transuranic mixed wastes and residues are combined.
RCRA Part B	CO-7890010526	Hazardous, low-level mixed waste, transuranic mixed waste residues	CDH	Permit effective October 1991 and has been modified six times. Permit currently includes 15 storage units. Other permit modification requests are pending CDH approval or are under preparation by RFP.

CAQCC Regulation No. 7

Under provisions of Regulation No. 7, all existing sources that generate volatile organic compounds (VOCs) are required to submit to the CDH a report that provides an inventory of all VOC point sources, operation source descriptions, actual and potential annual emissions, and discussions of reasonably available control technology (RACT). In response to this requirement, RFP originally submitted the *Volatile Organic Compound (VOC) Emissions Report* (EG91g) to CDH in December 1991. The basis of this report was the RFP air emission inventory documentation that provided VOC point-source information.

In November 1992, four pages of the report were revised and submitted to CDH. The revisions were prepared for clarification following discussions with CDH.

CAQCC Regulation No. 15

Title VI of the CAA, "Stratospheric Ozone Protection," requires the phase-out of production of Class I ozone-depleting substances (ODSs) by the year 2000. In February 1992, this phase-out deadline was accelerated to December 31, 1995. In addition, many new regulations concerning the use of ODSs are being promulgated at the state and federal level to implement other requirements of Title VI. Class I ODSs include carbon tetrachloride, 1,1,1-trichloroethene, and many commonly used refrigerants such as Freon-11 and Freon-12.

Regulation No. 15, "Regulation to Control Emissions of Ozone Depleting Compounds," is scheduled to become effective on January 30, 1993. This regulation requires refrigerant reclaiming and recycling, preventive maintenance plans, semiannual inspections, equipment registration, refrigerant tracking, annual reporting, and registration of personnel who handle refrigerants. Stationary refrigeration systems with a 500-horsepower (hp) or larger compressor must be registered with the state by July 1, 1993. Registration of smaller systems will be phased in every 6 months, ending with 100-hp systems by January 1, 1995.

ODSs are used throughout RFP for various cooling, refrigeration, fire protection, cleaning, and other activities. It has been estimated that at least 1,500 pieces of refrigerant-using equipment exist on plantsite. The AQD has been reviewing the new and proposed regulations, developing compliance strategies, and implementing appropriate corrective actions with applicable

plant organizations. In order to assess the full impact these regulations will have on RFP operations and personnel, a comprehensive sitewide inventory of all refrigerant-using equipment is currently underway. When completed, the inventory will allow AQD to determine which pieces of equipment on plantsite require registration and tracking based on the requirements of applicable state and federal regulations. The inventory also will be useful in planning the ultimate phase-out of ODS usage at RFP.

Other activities related to stratospheric ozone protection regulations are provided below.

Refrigerant Recycling and Tracking - In FY92, 10 refrigerant reclaim systems and 10 portable recovery units were purchased by AQD, supplementing 12 refrigerant reclaim systems and 15 backpack recovery units procured by the Waste Minimization program in FY91. Four 1,600-pound reclaimers and one 2,800-pound reclaimer are expected to be purchased in 1993. A refrigerant tracking form and computer database were established to maintain accurate and complete records of refrigerant usage at RFP, including refrigerant recycling, equipment repairs, preventive maintenance activities, and equipment upgrades.

Refrigerant Equipment Upgrades, Retrofits, or Replacements - A scope and estimate to plan and schedule the retrofit or replacement of 19 large chillers to use alternative refrigerants is being conducted, with scheduled completion anticipated in 1993. AQD plans to purchase and install high-efficiency purges, high-efficiency oil filters, and reseating pressure relief valves for major chiller equipment, helping minimize emissions to the lowest achievable level and conserving refrigerants that will no longer be produced in the United States after December 31, 1995. Future use of smaller chillers and refrigeration equipment on plantsite will be reviewed upon completion of the equipment inventory. Decisions also will be necessary concerning the future supply of refrigerants and/or replacement of the smaller equipment. AQD is developing a comprehensive refrigerant management plan to address these and other issues.

Mobile Sources - The RFP Garage established a tracking system to maintain accurate and complete records of air conditioner servicing and refrigerant usage in the

RFP vehicle fleet. Garage personnel acquired approved motor vehicle air conditioner (MVAC) recovery equipment, and six technicians completed approved certification programs and are authorized to operate the recovery equipment.

Class I and II Substance Usage Studies - The plantsite uses of Class I and Class II substances that are regulated under Title VI of the CAA, as amended, are currently being assessed. Two reports, *Ozone-Depleting Substance Phase-Out Plan* (EG92d), and *Review of Specifications and Requirements for Ozone-Depleting Substance Usage* (EG92g), were completed for submittal to DOE RFO and DOE HQ during October and November 1992, respectively. A third report, *Essential Uses of Ozone-Depleting Substances Proposed Chlorofluorocarbon Banking Program*, is expected to be submitted in early 1993. AQD will continue to work closely with the Procurement Department to ensure that restrictions are placed on equipment and chemical purchases involving Class I and Class II substances.

CLEAN WATER ACT (CWA)

The Clean Water Act (CWA), originally passed by Congress in 1972, established ambitious goals to control pollutants discharged to U.S. surface waters. Among the main elements of the CWA were nationally applicable, technology-based effluent limitations set by the EPA for specific industry categories and water quality standards set by states. The CWA also provided for the National Pollutant Discharge Elimination System (NPDES) permit program, requiring permits for discharges from a point source into surface waters. The first phase for expanding the NPDES to non-point sources is now underway with the issuance of storm water discharge permits to medium and large municipalities and sites with industrial activity.

The EPA and the State of Colorado both have roles in RFP's compliance with the CWA. While EPA Region VIII issues and administers the NPDES permit for RFP, the state, through the Colorado Water Quality Control Commission (CWQCC), sets surface water and groundwater quality standards for receiving streams and bodies of water, including standards for the creek segments immediately downstream of RFP's discharge points and the two reservoirs. The state also ratifies

issuance of the federal permit issued within its borders and has the ability to veto the permit if it does not contain sufficient terms to protect all ambient segment water quality standards in the receiving stream.

National Pollutant Discharge Elimination System (NPDES) Permit

The NPDES permit program controls the release of pollutants into United States waters and requires routine monitoring of point source discharges and reporting of results. RFP's first NPDES permit was issued by the EPA in 1974. The permit was reissued by EPA in 1984, expired in 1989, and was extended administratively until renewed. An updated renewal application was submitted.

The NPDES permit for RFP (#CO-0001333) identifies seven monitoring points for control of discharges (EPA84). Three of these discharge points, Ponds A-4, B-5, and C-2, are capable of discharging water offsite. The NPDES permit terms were modified by the NPDES Federal Facilities Compliance Agreement (FFCA), originally signed on March 25, 1991, by DOE and EPA, to eliminate two discharge points that were inactive (the Reverse Osmosis Pilot Plant and the Reverse Osmosis Plant) and to include new monitoring parameters at the other discharge locations. The current NPDES permit terms, which went into effect in April 1991, are summarized in Appendix B (Table B-4). The NPDES FFCA also required submittal of three compliance plans addressing administrative and physical changes to the plant. The three plans, the Groundwater Monitoring Plan for the Sewage Treatment Plant (STP) Sludge Drying Beds, STP Compliance Plan, and Chromic Acid Incident Plan and Implementation Schedule, were submitted in accordance with the agreement. Other revisions to the NPDES monitoring requirements included changing one "point of compliance" location from Pond B-3 to the STP discharge for most parameters. Monitoring requirements for total chromium and whole effluent toxicity (WET) at the terminal ponds and monitoring for metals, VOCs, and WET at the STP discharge also were added.

No Notices of Violation (NOVs) were received by RFP in 1992 for violation of NPDES standards. One exceedance (low pH at the STP) was reported by RFP on July 5, 1992. The cause was determined to be low flow, and action was taken immediately to correct the condition, which has not reoccurred.

The Agreement in Principle (AIP) established a procedure whereby RFP would provide CDH with split samples of water proposed for discharge from the terminal ponds. This allows CDH to assess water quality before a discharge. Samples are split for analysis by CDH, EG&G Rocky Flats, and independent EPA-registered laboratories. At present, once CDH has made its assessment and given concurrence for discharge, pond waters are discharged directly to the Broomfield Diversion Ditch.

The NPDES permit recommends, as a Best Management Practice (BMP), the maintenance of terminal pond water levels at a maximum of 10 percent of capacity to allow sufficient storage volume for spill containment and flood control. Because of inherent delays caused by concurrent sampling and analysis and continuing storage of inflows, Ponds A-4, B-5, and C-2 often hold more than 10 percent of pond capacity.

During 1992, project work continued to progress in relation to the three compliance plans required by the NPDES FFCA. The FFCA requires submittal of quarterly progress reports to the EPA updating the status and schedule of projects within each compliance plan. Accomplishments and activities that occurred in 1992 on the compliance plans are provided below.

Groundwater Monitoring Plan for the STP Sludge Drying Beds. A draft Groundwater Monitoring Plan was initially submitted to EPA in July 1990. The plan proposed a method for characterizing groundwater beneath the sludge drying beds located east of the STP. The EPA subsequently recommended a phased approach beginning with monitoring and characterization of soil and water in the vadose zone. The Vadose Zone Monitoring Plan was submitted to EPA and approved in June 1991. An addendum to the monitoring plan was submitted for two additional sludge drying beds located east of Building 910. Field work at both locations was initiated during 1992 and scheduled for completion in February 1993. Monitoring activities will continue at both sites for a 1-year period, with completion expected in February 1994.

STP Compliance Plan. The STP Compliance Plan, submitted to EPA in July 1990, described planned improvements to the STP necessary to meet NPDES water quality standards and FFCA criteria. Completed work includes implementation of recommendations

from diagnostic studies of treatment plant operations, installation of an autochlorination/dechlorination system, and additional influent and effluent instrumentation. Other planned improvements are included in a treatment plant upgrade project, which consists of three phases.

- Phase I includes construction of a mechanical sludge drying system and modifications to existing sludge beds to improve the efficiency of the sludge drying process. Construction is expected to be completed in April 1993.

- Phase II includes electrical improvements for improved reliability and additional capacity, emergency electrical power provisions, construction of an addition to the existing laboratory building, addition of equipment and controls at the equalization basins, upgrades to existing structures and equipment within the STP including the polymer feed system and sand filters, and additional chemical storage. Construction is expected to begin in 1994.

- Phase III includes construction of additional influent and effluent storage for the STP, modification of the existing plant to provide for nitrification, and construction of a new denitrification system. The final scope of Phase III will be addressed during the NPDES permit negotiations with the EPA.

Chromic Acid Incident Plan and Implementation Schedule. A Draft Chromic Acid Incident Plan was submitted to EPA in November 1990. The plan was prepared in response to recommendations made following a DOE investigation of an unplanned release of chromic acid solution from Building 444 during 1989. The plan addressed physical and administrative changes to reduce the possibility and impact of future spill events. A number of proposed actions were completed, and EPA agreed to refocus the remaining scope of the plan to emphasize issues relevant to surface water protection and source control. A draft plan incorporating the revised approach was submitted to EPA during the second quarter of 1992 and was approved in October 1992. Work was initiated in October 1992 on plan activities and is expected to be completed in March 1996.

Spill Prevention Control and Countermeasures/Best Management Practices Plan (SPCC/BMP)

The Spill Prevention Control and Countermeasures/ Best Management Practices Plan (SPCC/ BMP) is a compilation of existing facility improvements, operational procedures, policies, and requirements for control of hazardous substance and oil spills. The current SPCC/BMP was completed in September 1992.

Storm Water Permit Application

Since RFP is a site with industrial activity, it is required to submit an NPDES storm water permit application under regulations promulgated in November 1990. The original application deadline of November 17, 1991, was changed to October 1, 1992. A network of six storm water monitoring locations was established during 1991 with the approval of EPA, providing storm water quality information for runoff that leaves the core area of Rocky Flats. Automated sampling equipment collected flow-composited samples to characterize the runoff, while data loggers collected and stored flow information at each monitoring location. The storm water permit application was submitted in 1992 on schedule.

Colorado Water Quality Control Commission (CWQCC) Water Quality Standards

The Colorado Water Quality Control Commission (CWQCC) originally conducted a hearing in December 1989 on standards for surface waters draining into Standley Lake and Great Western Reservoir. These waters include Woman Creek and Walnut Creek, RFP's principal drainages. As a result of this hearing, the resegmentation of Big Dry Creek and revised use classifications and water quality standards for Woman Creek and Walnut Creek tributaries to Standley Lake and Great Western Reservoir became effective in March 1990. This action by the CWQCC established goal stream standards for Segment 5 of Big Dry Creek (tributaries from source to Ponds A-4, B-5, and C-2) and stringent stream standards for Segment 4 of Big Dry Creek (from pond outlets to Standley Lake and Great Western Reservoir). Goal standards differ from stream standards in that "goal" indicates that the waters are presently not fully suitable but are intended to become fully suitable for classified use, and that a temporary modification for one or more of the underlying numeric standards was granted. Stream standards were adopted for organic and inorganic chemicals, metals, radionuclides, and certain physical and biological parameters.

In October 1992, the CWQCC heard a petition by DOE to reconsider the standards placed on Segment 5 of Big Dry Creek. The standards are based on the designated use, or classification, of a water body segment (e.g., aquatic life, drinking water supply, recreational, agricultural). Segment 5 was subject to stream standards with goal qualifiers. At the October meeting, DOE and EG&G Rocky Flats requested an extension of the goal qualifiers and temporary modifications and asked the CWQCC to revise the site-specific organic standards to achieve consistency with the statewide numeric standards for organic chemicals. In December 1992, the CWQCC rejected the proposal to continue the narrative ambient modifiers for 3 additional years, and instead agreed to impose Segment 4 standards with temporary modifications for nine parameters. The CWQCC did accept several additional modifications to Segment 4 and 5 standards put forth by DOE/EG&G to make the specific standards consistent with statewide standards for organic constituents. The Commission also adopted a standard for beryllium.

SAFE DRINKING WATER ACT (SDWA)

The Safe Drinking Water Act (SDWA) establishes primary drinking water standards for water delivered by a public water supply system, defined as a system that supplies drinking water to either 15 or more connections or 25 individuals for at least 60 days per year. The RFP water supply system meets these criteria and is termed a noncommunity, nontransient system because persons who use the water do so on a daily basis but do not live at the site.

RFP periodically evaluates plant drinking water for various water quality parameters including primary and secondary water contaminants, inorganics, VOCs, and radionuclides. Results of these analyses are reported to the CDH weekly, monthly, quarterly, and annually depending on the type of analyses performed. A complete description of the Drinking Water Monitoring Program at RFP is given in the 1992 *Rocky Flats Plant Environmental Monitoring Plan* (EG92e).

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) governs the registration and use of pesticides, herbicides, and rodenticides. The FIFRA program at RFP tracks the materials from their initial purchase to final disposal and helps ensure that all pesticides on plantsite are registered with the EPA, are applied by licensed contractors, and that waste is properly disposed. In October 1992, the FIFRA program was moved from the Waste Guidance Programs organization to the Surface Water Division of Environmental Protection Management.

The Watershed Management Plan (WMP), currently in final draft form, includes the FIFRA program because the use of pesticides can affect stormwater runoff quality as well as waste streams, thus affecting areas covered by the CWA regulations as well as the waste minimization programs.

The FIFRA Program Management Plan is currently being prepared. Elements of the plan include preparation of a database of information regarding the application of pesticides on plantsite; an annual meeting with DOE concerning use of pesticides; monitoring of the FIFRA act for updates and changes, as well as monitoring of changes in pesticide approvals and regulations by the EPA; coordination with the Chemical Tracking and Control System (CT&CS) Division for tracking of pesticides on plantsite; ongoing evaluations of chemical use and efficacy; and a continual search for alternatives to pesticide use on plantsite.

TOXIC SUBSTANCES CONTROL ACT (TSCA)

The Toxic Substances Control Act (TSCA), administered by the EPA, requires testing and regulation of chemical substances that enter the environment. TSCA supplements sections of the CAA, the CWA, and the Occupational Safety and Health Act (OSHA). Compliance with TSCA at the RFP is directed at management of polychlorinated biphenyls (PCBs) and containerized waste asbestos from abatement projects.

In 1992, 89 drums of radioactive asbestos were shipped offsite. These drums consisted of low-level radioactively contaminated asbestos generated at several locations throughout RFP. The drums were shipped to the DOE Hanford site in Washington for disposal. RFP is continuing to explore the possibility of shipping low-level asbestos to Hanford as a small-quantity generator.

RFP also is continuing its efforts to ship low-level asbestos for disposal at the Nevada Test Site.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

The Resource Conservation and Recovery Act (RCRA) provides cradle-to-grave control of hazardous waste by imposing management requirements on generators and transporters of hazardous wastes and on owners and operators of treatment, storage, and disposal facilities. The State of Colorado, under authority of the EPA, regulates hazardous waste and the hazardous component of radioactive mixed waste at RFP. Strictly radioactive wastes are regulated by the Atomic Energy Act of 1954 as administered through DOE orders.

Colorado Hazardous Waste Act - Notice of Violation

On June 17, 1992, EG&G Rocky Flats received an NOV under the Colorado Hazardous Waste Act. The notice addressed 56 issues raised by the CDH, Hazardous Materials and Waste Management Division, over a 22-month period from July 1990 to June 1992. None of the findings involved offsite releases. The majority of the 56 issues were brought to the state's attention through the plant's own reporting system, and corrective actions were completed for nearly all of the findings. EG&G's review of the violations indicated that the root cause of most findings related to the level of personnel training regarding RCRA compliance and the management of hazardous waste. The violations fall into three basic categories: inadequate response to spills in buildings, ancillary equipment, tanks, and defective equipment; inadequate staff training; and improper or inadequate waste characterization.

In response to the NOV, EG&G developed more than 100 individual corrective action tasks to address the findings. Nearly all of the individual tasks were completed, with the exception of implementation of a centralized spill response team. That team is scheduled to be in place by June 1993.

DOE, RFO and EG&G also initiated additional actions designed to enhance regulatory compliance. Among those were development of an Environmental Compliance Pilot Program, a joint effort of the CDH, DOE, and EG&G. The pilot program initiated in two RFP buildings is part of a more comprehensive Rocky Flats Plant Site-Wide Environmental Compliance Program Management Plan, which is being developed

and whose strategic objectives focus on identification and planning to facilitate site-wide changes toward full environmental compliance. Also under development is a RCRA-related Comprehensive Hazardous Waste Compliance Program Plan, which addresses root cause analyses to avoid recurring deficiencies.

RCRA Part A and Part B Permit

The RCRA Part A permit application identifies (1) the facility location, (2) the owner and operator, (3) the hazardous and mixed wastes to be managed, and (4) the hazardous waste management methods. A facility that has submitted a RCRA Part A permit application is allowed to manage hazardous wastes under transitional regulations known as interim status pending issuance of a RCRA Operating Permit. The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous waste management. The RCRA Operating Permit is based on the RCRA Part B permit application and contains specific detailed operating conditions for the waste management units addressed by the permit. RCRA Parts A and B permit applications for RFP cover hazardous waste treatment and storage operations. RFP does not perform onsite hazardous waste disposal.

Part A Permit. Since the early 1980s, a series of RCRA Part A permit applications have been submitted to the CDH. During 1992, the Part A permit application was revised seven times to request changes to interim status and to support Part B permit modification requests. The revisions, dates submitted to CDH, and changes requested are provided below.

January 1992 - Revision 2, Combined Hazardous, Low-Level Mixed, TRU Mixed, and Mixed Residues Part A, requesting interim status for mixed residue units. This request was later withdrawn by RFP.

January 1992 - Revision 3, Combined Hazardous, Low-Level Mixed, TRU Mixed, and Mixed Residues Part A with Permit Modification Request Number 4 (modification discussed below).

May 1992 - Revision 4, Combined Hazardous, Low-Level Mixed, TRU Mixed, and Mixed Residues Part A. This revision is dated May 1992 but was actually submitted in November 1992. This change to interim status requested additional EPA waste codes for several interim status units.

June 1992 - Revision 5, Combined Hazardous, Low-Level Mixed, TRU Mixed, and Mixed Residues Part A with Permit Modification Request Number 8 (modification discussed below).

August 1992 - Revision 6, Combined Hazardous, Low-Level Mixed, TRU Mixed, and Mixed Residues Part A with Permit Modification Request Number 9 (modification discussed below).

July 1992 - Revision 7, Combined Hazardous, Low-Level Mixed, TRU Mixed, and Mixed Residues Part A. This change to interim status requested approval to operate a new unit for the solidification of Solar Pond sludge. This request was later put on hold by RFP.

November 1992 - Revision 10, Combined Hazardous, Low-Level Mixed, TRU Mixed, and Mixed Residues Part A with Permit Modification Request Number 12 (modification discussed below).

One other change to interim status was requested in a letter during 1992, which did not include a revised Part A permit application. This change requested temporary relocation of certain wastes in order to upgrade two permitted cargo container units. The request was submitted and approved in July 1992. In addition, CDH approved a change to interim status to treat low-level mixed waste and TRU mixed waste in the Supercompaction and Repackaging Facility (SARF) in June and July 1992. The request for this change was originally submitted to CDH in 1989.

Part B Permit. Seven requests for modification to the Rocky Flats Plant RCRA Part B Operating Permit were submitted to CDH in 1992. These requests are summarized below.

January 1992 - Permit Modification Request Number 4, a class II permit modification that added six new container storage areas and added EPA waste codes to several permitted units. A public review meeting was held in February 1992, and the request was approved by CDH in June 1992.

January 1992 - Permit Modification Request Number 5, a class III permit modification that revised Part VII (Personnel Training) of the permit. A public review meeting was held in February 1992. This modification request was later modified in November 1992 at CDH's

request. The request has not yet been approved by CDH.

February 1992 - Permit Modification Request Number 6, a class I permit modification that reformatted Part III (Storage in Containers) of the permit. This class I modification did not require a public comment meeting or CDH approval.

March 1992 - Permit Modification Request Number 7, a class I permit modification that reformatted the remainder of the permit. This class I modification did not require a public comment meeting or CDH approval.

June 1992 - Permit Modification Request Number 8, a class III permit modification that added mixed residue storage and treatment units to the permit. A public comment meeting was held in August 1992. The request has not yet been approved by CDH.

August 1992 - Permit Modification Request Number 9, a class III permit modification that added the Building 374 Waste System Upgrade equipment to the permit. A public comment meeting was held in October 1992. The request has not yet been approved by CDH.

November 1992 - Permit Modification Request Number 12, a class III permit modification that added 12 interim status units to the permit. A public review meeting was held in December 1992. The request has not yet been approved by the CDH.

Other permit modification requests are in development at RFP to add all interim status units and newly planned hazardous waste units to the RFP RCRA Part B operating permit.

In addition, a permit application supplement was submitted to EPA in February 1992 to address the requirements of the organic air emissions regulations, effective December 1990, and codified in 40 CFR 264 and 265, subparts AA and BB. EPA has not yet acted on this submittal. Negotiations will be required among the EPA, CDH, and RFP to determine how to incorporate this submittal into the RFP RCRA Part B operating permit.

RCRA Closure Plans

RCRA closure plans identify procedures for decontaminating/decommissioning hazardous waste management units from service to prevent both short- and long-term threats to human health and the environment. These plans describe measures to eliminate or minimize future maintenance of hazardous waste management units, to control releases of hazardous constituents, and to permanently close these units. Post-closure monitoring is required if "clean closure" of a unit under RCRA cannot be achieved.

Hazardous waste management units that operate under interim status (40 CFR 265) and units that operate under a permit (40 CFR 264) must be addressed in RCRA closure plans (40 CFR 264 and 265, Subpart G). Closure plans for facilities that begin or continue operation following the interim status period must be addressed in the RCRA Part B permit. Land-based hazardous waste management units that discontinue operation during the interim status period and that cannot be "clean closed" in accordance with applicable RCRA regulations must submit RCRA Part B post-closure care permit applications for interim status units. These are units that have been removed from service but require post-closure monitoring and maintenance.

The closure plans for the 15 permitted units are included in the RFP RCRA Part B operating permit. The closure plans for most interim status units are included in Part B operating permit modification requests submitted to CDH or in preparation at RFP. The closure plans for the remainder of interim status units for which RFP will not be seeking a RCRA operating permit will be updated during 1993 and submitted to CDH for approval.

Closure plans for the Solar Evaporation Ponds (Operable Unit 4 [OU 4]), Present Landfill (OU 7), Original Process Waste Lines (OU 9), and West Spray Field (OU 11) were originally submitted to the CDH in 1986 and 1988. These closure plans were later superseded by the January 1991 Inter-Agency Agreement (IAG). The IAG requires all interim status closure units to use a combination of RCRA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) criteria. The IAG requires RCRA Facility Investigations/Remedial Investigations (RFI/RI) work plans as a function of characterizing the

source of the contamination and the soils of an interim status closure unit. Draft Phase I RFI/RI work plans were submitted to the CDH and EPA in 1990 for several OUs. The RFI/RI work plan for the Present Landfill was approved December 12, 1991. The RFI/RI work plan for the Solar Evaporation Ponds received conditional approval on May 8, 1992, while conditional approval was received on April 29, 1992, for the RFI/RI work plan for the Original Process Waste Lines. Conditional approval for the West Spray Field RFI/RI was received on March 16, 1992, and for other Outside Closures (OU 10) on September 15, 1992.

Quarterly groundwater monitoring continued in 1992 for wells within three RCRA-regulated units scheduled for Interim Status Closure: the Solar Evaporation Ponds (OU 4), West Spray Field (OU 11), and Present Landfill (OU 7). Several new groundwater monitoring wells also were installed during 1992. Quarterly Assessment Reports were prepared highlighting results of groundwater sampling. The 1992 Annual RCRA Groundwater Monitoring Report was prepared for submittal to CDH and EPA in early 1993. Analysis and interpretation of groundwater monitoring data was used in the 1992 Annual Report to assess the impact on groundwater quality resulting from waste management activities at the RCRA units.

Quarterly sampling splits were performed during 1992 in which groundwater samples from wells downgradient of RFP were split to allow independent analysis by the CDH. Audits of field sampling activities and quarterly reporting also were performed in conjunction with CDH to assure compliance with applicable regulations.

RCRA Contingency Plan

The RCRA Contingency Plan (Part VI of the RCRA Permit) is designed to minimize the hazards to human health and the environment from fires, explosions, or any unplanned sudden releases of a hazardous waste or hazardous waste constituent to the environment (i.e., air, soil, or surface water). The plan may be implemented in the following situations.

- A release of a hazardous waste that results in an injury requiring more than first aid.
- A spill, leak, or release of a hazardous waste to the environment (air, soil, or surface water outside of a building) greater than 1 pint or 1 pound.

- A spill, leak, or other release of a hazardous waste inside a building that results in (1) a release that exceeds a reportable quantity as defined in Title 40 CFR 302, or (2) a release from a hazardous waste tank system that is not removed from its secondary containment system within 24 hours.

- A fire or explosion that involves a hazardous waste management unit or the release of a hazardous waste.

- Situations other than those outlined above can result in the implementation of the RCRA Contingency Plan at the discretion of the Emergency Coordinator.

In 1992, the RCRA Contingency Plan was implemented on 23 occasions. These implementation reports were forwarded to the CDH and described the magnitude of the releases, the actual or potential risks to human health and the environment, and the corrective actions taken to remediate the affected areas and systems.

Of the 23 occurrences that resulted in RCRA Contingency Plan implementation, 6 resulted from a lack of adequate secondary containment as required by RCRA regulations and 9 resulted from a waste being discovered in secondary containment, but not removed within 24 hours as required by RCRA regulations. Corrective actions were completed to address four of the six occurrences that resulted from a lack of adequate secondary containment. The two remaining areas requiring further attention, in Buildings 886 and 865, are scheduled to be corrected during 1993. The nine occurrences that resulted from a waste being discovered in secondary containment, but not removed within 24 hours, also were addressed. Daily inspections and other administrative controls were put in place to remove any accumulated liquids within the timeframes required by RCRA regulations. The remaining eight occurrences that resulted in RCRA Contingency Plan implementation were for the situations described below.

- Approximately 1 quart of hazardous material was released to the soil from spent Ni-Cad batteries during storage and prior to disposal.

- Fourteen used oil filters were inadvertently disposed in the Sanitary Landfill.

- Approximately 35 gallons of process aqueous waste containing chromium was released from a RCRA 90-day accumulation tank into the secondary containment system in Building 731. The secondary containment system was later determined to be inadequate and the material was not removed within the 24-hour time period required by RCRA regulations.

- A release of approximately 50 gallons of hazardous waste (oil solvent mixture) was discovered in a ventilation plenum. The release originated from a RCRA-regulated tank system in Building 774.

- Approximately 200 gallons of corrosive process aqueous waste were released from an accumulation tank in Building 460. The material was contained in the secondary containment system, but the secondary containment system was later found to be inadequate because 6 gallons of solution were recovered from behind the pit liner. The secondary containment system was repaired prior to the tank being returned to service.

- A contractor overturned a container of diesel fuel used to clean tools during a paving operation. The contractor cleaned up the spill using dirt from the roadside and mistakenly added it to a load of dirt going to the Sanitary Landfill. The contingency plan was implemented because the waste was mismanaged.

- A pump used to transfer waste from a holding tank in a valve vault in Building 428 to Building 374 for disposal failed and released approximately 100 gallons of corrosive process aqueous waste into the secondary containment system.

- A transfer line from the interceptor trench system north of the solar ponds separated and released approximately 490 gallons of water contaminated with trace amounts of listed hazardous waste solvents down the east side of the berm around Pond 207-B.

National Response Center (NRC) Notifications

In 1992, per the requirements of 40 CFR 302.6, RFP notified the National Response Center (NRC) of 32 releases to the environment of a hazardous substance that equaled or exceeded the reportable quantity. Twenty-nine of these releases involved small quantities (less than

10 gallons) of ethylene glycol/water mixtures. One of the releases involved a release of 28 pounds of asbestos in 40 pounds of insulation. The releases were immediately cleaned up, minimizing their impact to the environment. In addition, there were two releases of contaminated groundwater, which contained detectable levels of hazardous waste constituents. The released material was not recovered; however, the contaminant concentrations in the soil do not pose an unacceptable risk to human health or the environment. No notifications were made to the Local Emergency Planning Committees (LEPC) or State Emergency Response Commission (SERC) because exposure was limited to persons within the boundaries of the plant.

In 1992, per the requirements of 40 CFR 110.10, RFP notified the NRC of two releases of diesel fuel that resulted in an oil sheen on the spill control ponds. The response actions included removal of the oil sheen using absorbent materials.

Waste Minimization

The RFP Waste Minimization Program was active during 1992. Some of the more significant programmatic accomplishments that occurred during 1992 are reviewed below.

- A pilot project to evaluate commercial carbon dioxide pellet cleaning systems was completed. More than 4,000 pounds of uranium-contaminated scrap metal were cleaned and decontaminated, proving the technical and economic viability of the technology. The pilot project will lead to establishing full-scale operations in support of future decontamination and decommissioning (D&D) activities.

- Twelve refrigerant reclamation units were purchased and installed for plant air-conditioning and refrigeration systems. Work orders have been initiated to install high-efficiency purge valves, oil-filtration systems, and spring-loaded pressure relief valves.

- Conservation programs were initiated for hydraulic oils and machine coolants. Waste Minimization also incorporated oil testing into preventive maintenance work orders, and tested bacteria-resistant coolant and coolant filtration as a method of prolonging the life of metal-working fluids.

Significant gains also were achieved in efforts to reduce generation of radioactive and nonradioactive hazardous wastes. Total radioactive waste generation in 1992 was 1,142 cubic meters (m^3), down from 2,042 m^3 in 1991. Transuranic (TRU) waste generation during 1992 was 10.01 m^3, down from 18 m^3 generated in 1991. TRU mixed waste generation was 12.45 m^3, compared to 49 m^3 generated in 1991. A total of 678.71 m^3 of low-level waste was generated, a significant reduction from the 1,339.5 m^3 generated during 1991, while 440.39 m^3 of low-level mixed waste were generated during the year, compared to 968.8 m^3 in 1991.

Nonradioactive hazardous waste generation was reduced by 44 percent, from 39,042 kilograms in 1991 to 21,786 kilograms in 1992. TSCA-regulated waste decreased from 21,159 kilograms in 1991 to 1,506 kilograms in 1992, representing a 93 percent reduction.

Paper recycling increased 67 percent during 1992 to a total of 348.5 tons. In addition, 14.3 tons of cardboard were recycled during 1992.

Settlement Agreement and Compliance Order on Consent No. 89-10-30-01 (commonly referred to as "Residue Compliance Agreement")

On November 3, 1989, the DOE, CDH, and EPA signed the Settlement Agreement and Compliance Order on consent No. 89-10-30-01 regarding alleged violations of the RCRA hazardous waste regulations pertaining to proper waste management of residues. RFP submitted documents in compliance with this Consent Order, the last of which was the Mixed Residues Compliance Plan submitted September 28, 1990.

The Mixed Residues Compliance Plan was prepared to meet the requirements of the Settlement Agreement and Compliance Order on Consent, as well as to provide a schedule for compliance with the conclusions of the United States District Court for the District of Colorado in the Civil Action No. 89–B–181, Sierra Club, Plaintiff, vs. United States Department of Energy, and Rockwell International Corporation, a Delaware Corporation, Defendants. The Mixed Residues Compliance Plan included actions to bring residues into compliance with the Colorado Hazardous Waste Regulations found in 6 CCR 1007-3 Parts 100, 262, and 265, methods to minimize generation of RCRA-regulated residues, and actions to reduce the amount of RCRA-regulated residues in storage.

In May and June 1990, the Sierra Club amended its 1989 complaint (Civil Action No. 89-B-181) requesting that the court place a permanent or preliminary injunction against the DOE prohibiting the restart of RFP. This amended complaint alleged that the DOE was not managing hazardous waste at RFP in accordance with RCRA. On August 13, 1991, the United States District Court for the District of Colorado decided in partial favor of the Plaintiff for a permanent injunction in Civil Action No. 89-B-181, Sierra Club, Plaintiff, vs. United States Department of Energy, Defendant, stating that if the DOE does not obtain a permit for the mixed residues currently being stored without a permit or interim status within 2 years of the court judgment, the DOE shall conduct no operations (except for maintenance and safety activities to maintain the safety of RFP in a nonoperational status) that generate any hazardous waste or mixed radioactive and hazardous waste.

On July 31, 1991, the CDH issued to RFP Compliance Order No. 91-07-31-01, which indicated that the Mixed Residues Compliance Plan was inadequate and therefore violated the November 1989 order. In addition, on August 1, 1991, the CDH filed a complaint in court alleging that the DOE had submitted an inadequate plan in violation of the November 1989 Order and directing the DOE to meet the terms of the Compliance Order. Compliance Order No. 91-07-31-01 specified a schedule for removing all backlog mixed residues from RFP by January 1, 1999, and a schedule by which mixed residues would be brought into physical and administrative compliance with the Colorado Hazardous Waste Regulations.

In order to meet the court ordered deadline for obtaining a permit for all mixed residues currently stored at RFP, a Permit Modification request was submitted to the CDH on June 30, 1992. Work to upgrade mixed residue units to meet conditions of the Permit Modification was initiated and continued throughout 1992. In addition, the Permit Modification included a compliance schedule for submitting closure plans for out-of-service mixed residue units. In accordance with the compliance schedule, closure plans were submitted for out-of-service tank systems in Buildings 371 and 771 on September 11, 1992, and December 13, 1992, respectively.

Negotiations to resolve CDH's August 1991 suit continued throughout 1992. As part of those negotiations, a Mixed Residue Reduction Report was submitted on February 28, 1992, and a Mixed Residue Tank Systems Management Plan was submitted on March 31, 1992. The Tank Systems Management Plan, which was updated in August 1992, included schedules to bring mixed residue tank systems into compliance with the Colorado Hazardous Waste Regulations. The Mixed Residue Reduction Report, which was updated in November 1992, included preliminary plans for removing the inventory of mixed residues from RFP.

Federal Facilities Compliance Agreement (FFCA) for Land Disposal Restricted Waste

After the first compliance order on consent was signed by the DOE, EPA Region VIII, and the State of Colorado on September 19, 1989, a second compliance agreement, referred to as Federal Facilities Compliance Agreement-II (FFCA), was executed on May 10, 1991, between the DOE and EPA. FFCA-II was entered into by the DOE and EPA to provide a 24-month period for DOE to demonstrate achievements toward compliance with the LDR portions of the Hazardous and Solid Waste Amendments (HSWA) of 1984 and the Colorado state laws applicable to RFP. The new agreement is an expansion of the original FFCA, and provides the mechanism for DOE to achieve compliance with the LDR portion of RCRA regulations. The FFCA covers radioactive wastes that do not meet treatment standards specified by EPA, or wastes that contain hazardous constituents above the applicable allowable levels for land disposal. During the period of FFCA-II, DOE agreed to take all feasible steps to ensure accurate identification, safe storage, and minimization of restricted waste prohibited from land disposal.

During 1992, a variety of reports and plans were prepared and submitted to meet the requirements of the FFCA-II. These reports and plans outline the development and implementation of various treatment technologies required to treat mixed wastes before disposal at offsite locations. Under the terms of the agreement, most of these documents are subject to review and/or approval by the EPA. A brief summary of each of these reports and plans is provided below.

- *Comprehensive Treatment and Management Plan (CTMP)* - The CTMP identifies and describes the treatment and management methods planned to bring

RFP LDR wastes into compliance with LDR regulations. The CTMP includes draft schedules and milestones for developing and implementing treatment technologies. The milestones set forth in the CTMP become enforceable milestones upon approval of the document by the EPA. The CTMP, version 1.3, was published June 9, 1992.

- *Annual Waste Minimization Plan* - This plan highlights progress in waste minimization efforts at RFP. The 1992 Annual Report on Waste Generation and Waste Minimization Progress, which was submitted to the EPA on May 28, 1992, is the primary source for documentation of these efforts.

- *Annual LDR Progress Report (APR)* -This report provides an update and status on the progress to achieve compliance with the terms and conditions of FFCA-II. The APR includes quantities of waste in storage, storage locations, progress in LDR determinations, waste characterization efforts, treatment technology implementation, nonradioactive hazardous waste shipping schedules, residue management, and waste minimization status. The APR is due on March 31 of each year under terms of the FFCA-II. The first APR was submitted to the EPA on March 31, 1992.

- *Residue Management Report* - This report describes the plans for bringing the management of mixed residues into compliance with LDR requirements. Under the Mixed Residue Compliance Order, a Mixed Residue Reduction Report (MRRR) was prepared and submitted to the CDH for approval on February 28, 1992, and an updated Annual Mixed Residue Reduction Report (AMRRR) was submitted for approval on November 13, 1992. These reports describe plans to treat mixed residues as necessary to allow for storage or disposal. The MRRR, in combination with the AMRRR, satisfies the requirement for the Residue Management Report under terms of FFCA-II. The MRRR indicates that LDR mixed residues are being managed by the plans set forth in four documents: the Mixed Residue Compliance Plan as amended, the Mixed Residue Tank Management Systems Management Plan, the Mixed Residue Reduction Report, and the Backlog Residue Analytical Plan. The provisions for management of LDR residues described in these documents have been implemented.

- *Nonradioactive Hazardous Waste Shipping Schedule* - This document identifies the mechanisms and schedules by which nonradioactive hazardous wastes are characterized and transported offsite for disposal. These schedules are part of the Nonradioactive Hazardous Waste Certification & Disposal Plan, which DOE submitted to EPA on January 10, 1992. A revision to this document was made on June 24, 1992, to incorporate comments received from the EPA. Schedules for the identification, certification, and disposal of a variety of specific wastes are provided in this plan.

- *Waste Stream and Residue Identification and Characterization (WSRIC) Books* - These books provide updated information on the waste streams and residues generated or stored at RFP. The revised WSRIC books were submitted to EPA on September 10, 1992.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its major amendments (Superfund Amendment and Reauthorization Act [SARA]) provide funding and enforcement authority for restoration of hazardous substance sites (primarily inactive sites) and for responding to hazardous substance spills. Sites contaminated by past activities must be investigated and remediation plans developed and implemented. The intent of these actions is to minimize the release of hazardous substances, pollutants, or contaminants, thereby protecting human health and the environment. CERCLA requirements are addressed in a series of sequential phases intended to identify, design, and complete restoration of contaminated sites. CERCLA activities at RFP are dictated by the IAG.

RFP was initially added to the National Priorities List (NPL) on October 4, 1989. The NPL is an ordered ranking of CERCLA sites evaluated using the Hazardous Ranking System. If a site scores above a certain threshold level established by EPA, the site is placed on the NPL.

INTER-AGENCY AGREEMENT (IAG)

The IAG for environmental restoration activities at RFP was signed on January 22, 1991, by DOE, EPA, and the CDH. Officially called a Federal Facility Agreement and Compliance Order, the agreement replaced the 1986

RCRA-CERCLA Compliance Agreement and clarified the responsibilities and authorities of the three agencies, standardized requirements, described the procedures to be followed, and helped ensure compliance with orders and permits. The agreement also specifies delivery of major reports, project management activities and milestones, and includes community involvement and decision-making responsibilities. The agreement outlines each agency's role in, and integrates the authority/jurisdiction of, RCRA and CERCLA over the study and cleanup process. It also provides mechanisms for resolving issues that may arise among the participants during cleanup activities. The IAG and the Five-Year Plan (FYP) are the principal documents guiding RFP cleanup efforts.

The draft IAG was originally issued for public comment in December 1989 and submitted for official approval in August 1990, with changes reflecting comments received from the public. The final IAG was substantially the same as the draft IAG. The most visible modifications were the reprioritization of the RFP OUs and changes in the OU milestone schedules. (The current prioritization of OUs is provided in Table 2-3.) The OU reprioritization necessitated adjustments in the timelines associated with the individual OUs to reflect more realistic schedules for completion of the various studies required. The IAG requires that DOE notify the public of any schedule changes to those set forth in the final IAG. The final IAG also stipulates that various additional measures be taken for improved public involvement and directs DOE to address these public involvement commitments in the Community Relations Plan (CRP).

Documents prepared in accordance with the IAG cover a range of topics including remedial investigation work plans, interim remedial action decisions, community survey plans, project management plans, and health and safety plans. A series of monthly and quarterly Environmental Compliance Action reports document progress against IAG milestones (DOE92a, DOE92b). Table 2-4 lists the IAG milestones completed during 1992. Section 4 of this report, "Environmental Remediation Programs," describes remediation activities accomplished at RFP during 1992.

Table 2-3
Prioritization of Operable Units by the IAG

OU Number Under Final IAG (effective 1-11-91)	Description
01	881 Hillside Area
02	903 Pad Area
03	Offsite Areas
04	Solar Ponds
05	Woman Creek
06	Walnut Creek
07	Present Landfill
08	700 Area
09	Original Process Waste Lines
10	Other Outside Closures
11	West Spray Field
12	400/800 Area
13	100 Area
14	Radioactive Sites
15	Inside Building Closures
16	Low-Priority Sites

Table 2-4
IAG Milestones Completed in 1992

IAG Milestone	Operable Unit
Complete IM/IRA[a] Construction (Treatment Plant)	1
Complete IM/IRA Construction (French Drain)	1
Submit Draft Phase III RFI/RI[b] Report	1
Submit Draft Treatability Test Report (Phase 1 GAC [c])	2
Complete IM/IRA Construction (Rads Removal System)	2
Begin Field Treatability Testing (Rads Removal System)	2
Submit Final Treatability Test Report (Phase I GAC)	2
Submit Subsurface Final RS[d] and IM/IRAP/EA[e]	2
Submit Subsurface Site 1 Draft Test Plan	2
Submit Draft Phase I RFI/RI Work Plan	8
Submit Final Phase I RFI/RI Work Plan	8
Submit Final Phase I RFI/RI Work Plan	10
Submit Final Phase I RFI/RI Work Plan	11
Submit Draft Phase I RFI/RI Work Plan	12
Submit Final Phase I RFI/RI Work Plan	12
Submit Draft Phase I RFI/RI Work Plan	13
Submit Final Phase I RFI/RI Work Plan	13
Submit Draft Phase I RFI/RI Work Plan	14
Submit Final Phase I RFI/RI Work Plan	14
Submit Draft Phase I RFI/RI Work Plan	15
Submit Final Phase I RFI/RI Work Plan	15
Submit Draft No Further Action Justification Document	16
Submit Final No Further Action Justification Document	16
Submit Draft Historical Release Report	Sitewide
Submit RS Discharge Limits for Radionuclides	Sitewide
Submit Final Historical Release Report	Sitewide

a. Interim Measures/Interim Remedial Action
b. RCRA Facility Investigation/Remedial Investigation
c. Granular Activated Carbon
d. Responsiveness Summary
e. Interim Measures/Interim Remedial Action Plan/Environmental Assessment

Remediation Goals

The CERCLA requires that remediation goals comply with applicable or relevant and appropriate requirements (ARARs) of federal laws or more stringent promulgated state laws in relation to cleanup standards. ARARs are generally dynamic in nature in that they evolve from general to very specific during the CERCLA Remedial Investigation/Facilities Study (RI/FS) process. Final remediation objectives are comprised of both ARARs and risk assessment information and will be determined in the Record of Decision (ROD). The development of cleanup standards at RFP follow the general procedures described below.

Initially, during the RFI/RI work plan stage, potential chemical-specific ARARs are identified, usually based on a limited amount of data. Chemical-specific ARARs at this point have meaning only in that they may be used to establish appropriate detection limits so that data collected during the RFI/RI may be compared to ARAR standards. As more information becomes available during the RFI/RI stage, chemical-specific ARARs may become more refined as constituents are added or deleted. Detailed, location-specific ARARs are proposed in the RFI/RI report as the result of the RFI/RI process. This is followed by action-specific ARARs and remediation goals that are identified through the Corrective Measures Study/Feasibility Study (CMS/FS). A discussion is provided in the CMS/FS report for each remedial alternative regarding the rationale for all ARAR determinations. Once a preferred remedial action alternative is formally selected in the ROD, all chemical-, location-, and action-specific ARARs are also defined in final form. CERCLA requires that remediation programs attain ARARs and are protective of human health and the environment.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT (EPCRA)

The Emergency Planning and Community Right-to-Know Act (EPCRA) was enacted as a freestanding provision of the SARA in 1986. Also known as SARA Title III, EPCRA contains four major provisions.

- Chemical emergencies planning
- Emergency notification of chemical accidents and releases
- Hazardous chemical inventories reporting
- Toxic chemical release reporting

These provisions require facilities such as RFP to notify state and local emergency planning entities of the presence of potentially hazardous substances in their facilities and to report on the inventories and environmental releases of those substances. The intent of these requirements is to provide the public with information on hazardous chemicals in their communities, enhance public awareness of chemical hazards, and facilitate development of state and local emergency response plans.

Sections 301 and 302

Under Sections 301 and 302, the EPA requires the establishment of a State Emergency Response Commission (SERC), which is responsible for the formation of emergency planning districts, and Local Emergency Planning Committees (LEPC). Also under these requirements, facilities that produce, use, or store listed substances above the threshold planning quantity must notify the SERC and the LEPCs. RFP participates in the activities of the LEPCs established under these sections for emergency planning at the county level of government. RFP also maintains an emergency preparedness document for the plant and conducts annual mock emergency response scenarios to determine the effectiveness of the plan and the ability of plant organizations to respond.

Section 304

Section 304 applies to releases of extremely hazardous substances listed under EPCRA Section 302 and hazardous substances designated under Section 102 of CERCLA that exceed their reportable quantities and have the potential for impact beyond the plant boundaries. If the release is determined not to pose a potential impact beyond the plant boundaries, then reporting is not required under SARA Section 304. However, if a chemical is listed on the CERCLA Hazardous Substances list, reporting to the National Response Center may still be required under CERCLA Section 103(d). When a release occurs that is subject to Section 304, the facility owner or operator must notify the SERC and LEPC immediately by telephone and again in writing as soon as practicable. Section 304 requirements apply specifically to facilities such as RFP that produce, use, or store one or more hazardous chemicals as defined by the OSHA Hazard Communication Standard. The Waste Regulatory Programs group of RFP's Waste Programs Department directs EG&G's Occurrence Notification Center (ONC) to complete these notifications if such releases occur.

In 1992, there were no releases of extremely hazardous substances or CERCLA hazardous substances that posed a potential impact beyond RFP boundaries and required notification to the SERC and LEPCs.

Section 311

Under Section 311, facilities must submit to the SERC, LEPC, and the fire departments copies of Material Safety Data Sheets (MSDSs), or a list of all chemicals above certain thresholds that are defined as hazardous by the OSHA Hazard Communication Standard. Following the initial submittal, Section 311 requires the submittal of updates within 3 months for new chemicals that become subject to the OSHA Hazard Communication Standard or after discovering new information. This information was provided to the SERC, LEPC, and the fire department by RFP's Industrial Hygiene Department in 1987 to meet the original requirements. MSDS updates have continued to be provided to these agencies as required.

Section 312

Section 312 of EPCRA requires facilities to prepare an annual report titled "Tier II Emergency and Hazardous Chemical Inventory Forms," listing the ranges of quantities and locations of hazardous and extremely hazardous chemicals, or a "Tier I" chemical list report. This section covers hazardous chemicals under OSHA's Hazard Communication Standard (with limited exceptions) that are stored at a facility in excess of 10,000 pounds (hazardous) or in excess of a chemical-specific listed Threshold Planning Quantity (extremely hazardous), or 500 pounds, whichever is lower. Any facility required to prepare or have available an MSDS for a hazardous chemical under OSHA's Hazard Communication Standard must submit Tier I information on a form or, if requested or in lieu of Tier I submittal, Tier II information to the SERC, LEPC, and the local fire department. The Tier I or Tier II information must be submitted annually, beginning on March 1, 1988. RFP submitted this report to the following agencies for the calendar year 1992 report: Colorado Emergency Planning Commission, Jefferson County Emergency Planning Committee, Boulder County Emergency Planning Committee, and the Rocky Flats Fire Department (jurisdictional fire department).

Section 313

Section 313 of EPCRA requires that facilities prepare an annual report titled "Toxic Chemical Release Inventory, Form R," if annual usage quantities of listed toxic chemicals exceed certain thresholds. The threshold chemical usage quantities for 1992 are provided below.

- 25,000 pounds for listed chemicals either manufactured or processed.
- 10,000 pounds for listed chemicals otherwise used.

Facilities must report quantities of both routine and accidental releases of listed chemicals, maximum amount of the listed chemical stored onsite during the calendar year, and amount contained in waste transferred offsite. The owner or operator of the facility on the reporting date, July 1 of each year, is primarily responsible for reporting the data for the previous year's operations at that facility. Any other owner or operator of the facility from January 1 of the data generation year to June 30 of the reporting year may also be held liable. RFP submitted this report to the EPA and to the State of Colorado in 1992 detailing the chemicals used in 1991 (Table 2-5). Chemical usage for 1989 and 1990 also are reported in Table 2-5 for comparison purposes.

Table 2-5

Chemicals and Quantities (lbs) Used in 1989, 1990, and 1991 as Reported on Form R Reports

Chemical	1989	1990	1991
Nitric acid	223,387	10,244	11,824
Sulfuric Acid	58,300	-	-
Carbon tetrachloride	48,212	-	-
1,1,1-trichloroethane	45,634	-	-
Phosphoric acid	44,195	-	-
Hydrochloric acid	27,575	12,785	-
Ethylene glycol	13,423	-	-
Freon 113	12,545	-	-

Carbon tetrachloride and Freon 113 were used in decreasing quantities at RFP between 1988 and 1990 as a result of waste minimization efforts and the curtailment of plant operations and were used in quantities less than 10,000 pounds in 1990. Many chemicals reported in 1989 do not appear on the 1990 and 1991 lists because of RFP waste minimization efforts and the curtailment of plant operations.

AGREEMENT IN PRINCIPLE (AIP)

An Agreement in Principle (AIP) was executed between DOE and the State of Colorado on June 28, 1989. This agreement identified additional technical and financial support by DOE to Colorado for environmental oversight, monitoring, remediation, emergency response, and health-related initiatives associated with RFP. The agreement also addressed RFP environmental monitoring initiatives and accelerated cleanup where contamination may present an imminent threat to human health or the environment. The agreement is designed to ensure citizens of Colorado that public health, safety, and the environment are being protected through accelerated existing programs and substantial new commitments by DOE and through vigorous programs of independent monitoring and oversight by Colorado officials.

Programs and projects put in place under this agreement included the air emissions inventory (see CAA earlier in this section) and concurrent sampling of pond discharges (see CWA earlier in this section) and the Rocky Flats Toxicologic Review and Dose Reconstruction Study (CDH92). This study, conducted by the CDH, is intended to examine chemical and radionuclide emissions from RFP and assess what health impacts, if any, may have occurred to the public. Phase I of the study, the final draft report of the Reconstruction of Historical Rocky Flats Operations & Identification of Release Points, was issued in August 1992. This is being followed by Phase II of the study, which will provide estimates of exposure risks. Completion of Phase II is expected in late 1993. Funding for the health studies is provided by the DOE.

SPECIAL ASSIGNMENT TEAM

On June 6, 1989, DOE mobilized a Special Assignment Team (Tiger Team) to provide an independent audit of operations and practices at RFP. This followed initiation of a search warrant by the EPA, Federal Bureau of Investigation (FBI), and the Justice Department based on an affidavit alleging regulatory and criminal violations of environmental laws at the RFP. The Justice Department conducted the investigation, and a federal grand jury was convened to review RFP compliance with applicable environmental laws. In March 1992, former RFP operator Rockwell International Corporation agreed to plead guilty to 10 counts of environmental violations during its operation of RFP and agreed to pay $18.5 million in fines. Rockwell pled

guilty to four felony violations of RCRA and to one felony and five misdemeanor violations of the CWA. The plea agreement was subsequently approved by the U.S. District Court.

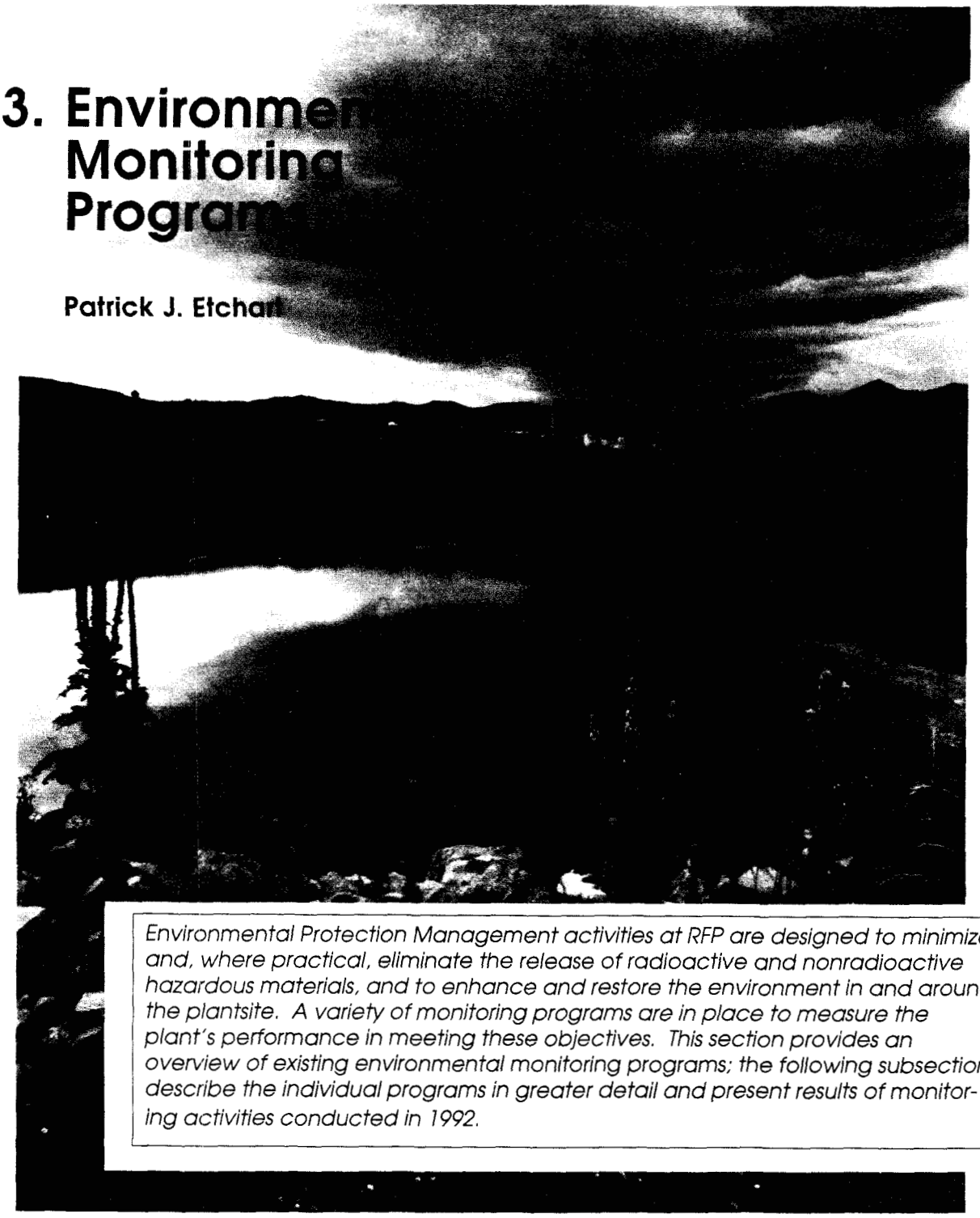
The original Tiger Team audit was completed on July 21, 1989, and results were reported in the *Assessment of Environmental Conditions at the Rocky Flats Plant* (DOE89). The objectives of the audit were to determine whether any imminent threat existed to public health or the environment as a result of RFP activities; whether RFP operations were being conducted in accordance with applicable environmental requirements and best management practices; and the current status of previously identified environmental problems. Areas examined included environmental monitoring, site remediation, waste management, quality assurance, sewage treatment plant operation, waste stream characterization, and environmental impact analysis. The audit resulted in the identification of 52 findings, 43 recommendations for best management practices, and 4 noteworthy practices. No situations were observed that posed an imminent threat to public health or the environment. The 52 findings were identified among air monitoring programs (5), surface water (7), groundwater (2), waste management activities (10), toxic and chemical materials (9), radiation (5), quality assurance (2), inactive waste sites and releases (6), and NEPA (6).

EG&G Rocky Flats, Inc., responded to findings of the Special Assignment Team in the *Corrective Action Plan in Response to the August 1989 Assessment of Environmental Conditions at the Rocky Flats Plant* (EG90c). That document outlined 93 separate action plans containing descriptions of measures to be taken by RFP to address findings and includes schedules, milestones, associated costs, and parties responsible for implementing planned actions. Many of the activities described in the plan overlap, or are similar to actions specified in the AIP and IAG and to the RFP Five-Year Plan (FYP) for environmental and waste programs (EG93a). Progress associated with these action plans has been described in quarterly reports titled *DOE Quarterly Environmental Compliance Action Report* (DOE92b).

The status of action plans is monitored and tracked in the Plant Action Tracking System (PATS), managed by the Commitments Management Department. Plan status may be "open," meaning that work continues on one or more tasks within an action plan; "in verification," meaning that the plan manager has certified that plan activities are complete and this is being verified; "reopened," meaning that not all plan tasks were verified as complete and further work is required; and "verified complete," meaning that all tasks have been completed and verified. As of December 1992, 37 action plans were verified as complete, 33 plans were in verification, and 23 plans were open.

3. Environmental Monitoring Program

Patrick J. Etchart



Environmental Protection Management activities at RFP are designed to minimize and, where practical, eliminate the release of radioactive and nonradioactive hazardous materials, and to enhance and restore the environment in and around the plantsite. A variety of monitoring programs are in place to measure the plant's performance in meeting these objectives. This section provides an overview of existing environmental monitoring programs; the following subsections describe the individual programs in greater detail and present results of monitoring activities conducted in 1992.

OVERVIEW

Specific operations at RFP involve or produce liquids, solids, and gases containing radioactive and nonradioactive potentially hazardous materials. Various environmental programs monitor penetrating ionizing radiation and pertinent radioactive, chemical, and biological pollutants. Data on air, surface water, groundwater, and soils provide information to assess immediate and long-term environmental consequences of normal and unplanned effluent discharges and actual or potential exposures to critical populations. Site-specific data are used to evaluate risk to humans and to assist in the warning of unusual or unforeseen conditions. Routine reports to local, state, and federal agencies and to the public provide information on the performance of these programs in maintaining and improving environmental quality and public health and safety. Table 3-1 provides a list of these reports. Table 3-2 contains the primary environmental compliance standards and applicable regulations for environmental monitoring programs at RFP. Additional compliance standards for air, surface water, and groundwater programs are given under references EG92f, EG92b, and EG91h, respectively.

Among the reports prepared annually is the *Rocky Flats Plant Environmental Monitoring Plan* (EG92e), which describes environmental monitoring programs at RFP. Monitoring programs provide current information on impacts to the environment and characterize environmental degradation at sites throughout RFP to identify contaminated areas and to design and monitor restoration activities.

Sections 3.1 through 3.6 of this report summarize results of routine environmental monitoring programs during 1992. Appendix D provides a detailed explanation of the sampling procedures used by laboratories and defines detection limits and error term propagation. Results are commonly compared to appropriate guides and standards that establish limits for radioactive and nonradioactive effluents. Persons unfamiliar with these standards are encouraged to review Appendix B, "Applicable Guides and Standards."

Table 3-1
RFP Environmental Reports

Regulatory Report [a]	Agency [b]	Frequency
Air Compliance Report (40 CFR 61.94)	EPA	Annual
Effluent Information System/Onsite Discharge Information System	DOE	Annual
Environmental Protection Implementation Plan	DOE	Annual
Emergency and Hazardous Chemical Inventory Forms (Tier II)	c	Annual
Toxic Chemical Release Inventory (Form R)	EPA	Annual
National Pollutant Discharge Elimination System/Discharge Monitoring Report	EPA	Monthly/ Annual
Polychlorinated Biphenyls (PCB) Inventory	EPA	Annual
Resource Conservation and Recovery Act Groundwater Monitoring Report	EPA/CDH	Annual
Rocky Flats Monthly Environmental Monitoring Report	DOE/EPA/CDH/ County/City	Monthly
Rocky Flats Plant Site Environmental Report	DOE	Annual
Environmental Monitoring Plan	DOE	Annual
Air Quality Management Plan	DOE	Annual
Surface Water Management Plan	DOE	Annual
Groundwater Protection and Monitoring Program Plan	DOE	Annual
Background Geochemical Characterization Report	EPA/CDH	Annual

a. Reports on major environmental programs prepared on a periodic basis
b. EPA - Environmental Protection Agency; DOE - Department of Energy; CDH - Colorado Department of Health;
County - Jefferson
Cities - Arvada, Broomfield, Westminster, Denver, Boulder, Northglenn, Fort Collins, Thornton
c. Colorado Emergency Planning Commission
Jefferson County Emergency Planning Committee
Boulder County Emergency Planning Committee
Rocky Flats Fire Department

Table 3-2

Primary Compliance Standards and Applicable Regulations for Environmental Monitoring Programs

Monitoring Program	Compliance Standards
AIR	
Effluent Air	• Standards for Performance for New Stationary Sources (Title 40 CFR 60) • National Emission Standards for Hazardous Air Pollutants (Title 40 CFR 61) • Colorado Air Quality Control Regulations #3, #6, #7, #8, and #15 (Title 5 CCR 1001) • General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Nonradioactive Ambient Air	• National Ambient Air Quality Standards and State Implementation Plans (Title 40 CFR 50), Requirements for Preparation, Adoption, and Submittal of Implementation Plans (Title 40 CFR 51), and Approval and Promulgation of Implementation Plans (Title 40 CFR 52) • Colorado Air Quality Control Commission Regulations #1, #2, #3, and #8 (Title 5 CCR 1001) • Colorado Air Pollution Control and Prevention Act, 1992 (Title 25 CRS, Article 7, Part 1) • General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Radioactive Ambient Air	• General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B) • National Emission Standards for Hazardous Air Pollutants (Title 40 CFR 61, Subpart H)
SURFACE WATER	
Surface Water	• National Pollutant Discharge Elimination System (Title 40 CFR 22, 125) • Colorado Water Quality Control Commission Surface Water Standards (Title 5 CCR 1000) • General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Community Water	• National Interim Primary Drinking Water Regulations (Title 40 CFR 141) • Colorado Primary Drinking Water Regulations (Title 5 CCR 1002) • General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
GROUNDWATER	• Comprehensive Environmental Response, Compensation and Liability Act (Title 42 U.S.C. 9601) • Resource Conservation and Recovery Act (Title 42 U.S.C. 6901) • Colorado Hazardous Waste Management Act (Title 25 CRS, Article 15) • General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B) • Colorado Water Quality Control Commission Groundwater Standards
SOILS	• United States Atomic Energy Commission, Rocky Flats Plant, 1973 Environmental Surveillance Summary Report • General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
RADIATION DOSE	• Radiation Protection of the Public and the Environment (DOE Order 5400.5) • General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)

In addition to the environmental programs performed by EG&G Rocky Flats, several local, state, and federal government agencies conduct independent audits and environmental surveys within and adjacent to RFP. The CDH, DOE, and the cities of Broomfield and Westminster conduct various air, water, and soil monitoring programs. Data are reported collectively at monthly Environmental Monitoring Information Exchange Meetings. RFP provides monthly environmental monitoring summaries at these meetings, which are open to the public and have been ongoing since the early 1970s.

THE FIVE-YEAR PLAN (FYP) AND THE SITE-SPECIFIC PLAN (SSP)

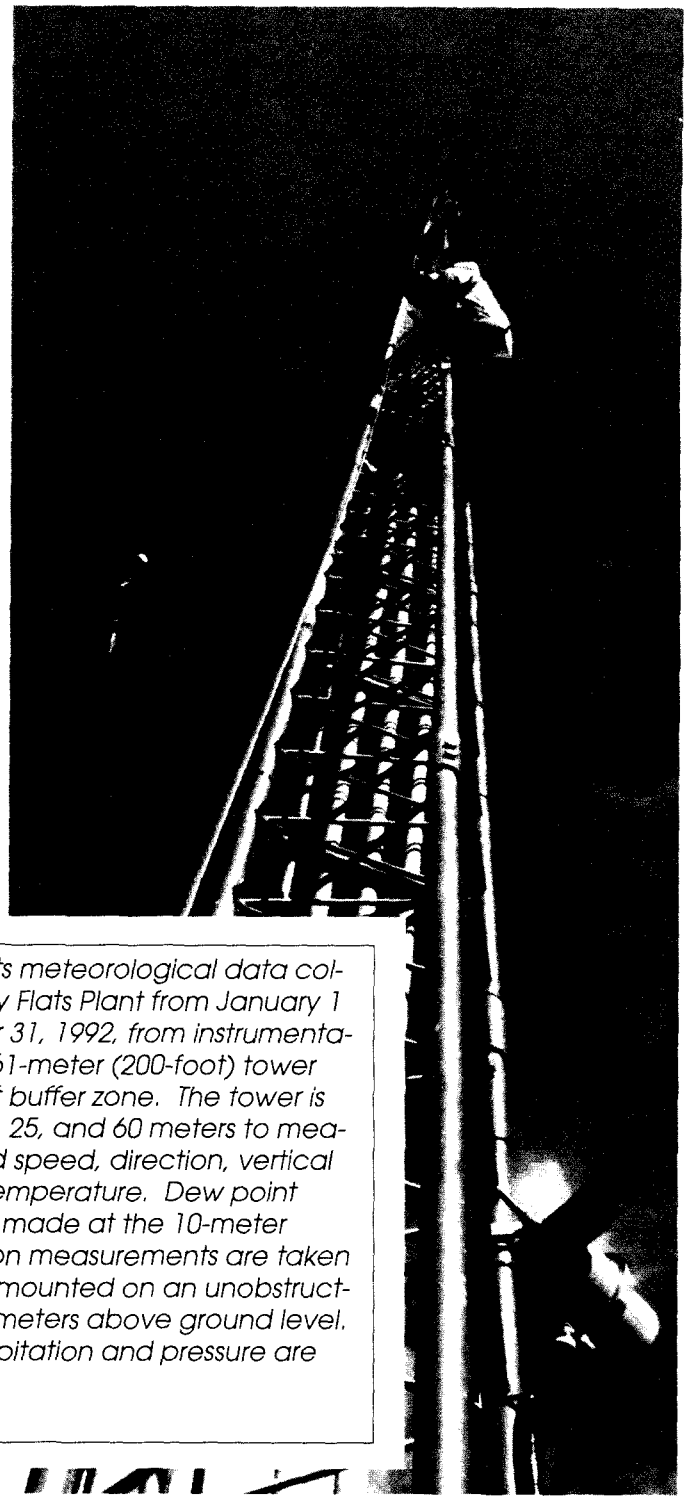
The purpose of the Five-Year Plan (FYP) is to establish an agenda for compliance and cleanup against which progress can be measured. The plan is revised annually, incorporating a 5-year planning horizon, and supports an annual national plan that is issued under the same title. A draft plan for fiscal years 1995-1999, titled *Rocky Flats Plant Draft FY95-99 Five-Year Plan* (EG93d), was prepared for review in the first part of 1993. The FYP encompasses total program activities and costs for DOE Environmental Restoration, Waste Management, and Technology Development activities. Hazardous, radioactive, mixed (hazardous and radioactive), and sanitary wastes are addressed, as well as facilities and sites that are either contaminated with wastes or used in the management of those wastes.

A Site-Specific Plan (SSP) is prepared to describe how activities shown in the FYP would be implemented at RFP. This plan is revised annually and emphasizes near-term activities, primarily those to be accomplished in a fiscal year. The final plan for FY93 was prepared for distribution in the first quarter of CY93.

3. Environmental Monitoring Programs

3.1 Meteorological Monitoring and Climatology

Brent M. Bowen



This section presents meteorological data collected at the Rocky Flats Plant from January 1 through December 31, 1992, from instrumentation installed on a 61-meter (200-foot) tower located in the west buffer zone. The tower is instrumented at 10, 25, and 60 meters to measure horizontal wind speed, direction, vertical wind speed, and temperature. Dew point measurements are made at the 10-meter level. Solar radiation measurements are taken by a pyranometer mounted on an unobstructed platform at 1.5 meters above ground level. Ground-level precipitation and pressure are also measured.

OVERVIEW

RFP's climate is temperate and semiarid, characteristic of Colorado's Front Range. The climate also is continental, since temperatures are largely determined by air masses that form over the land of North America. This results in large seasonal temperature variations and, occasionally, dramatic short-term temperature changes. The thin, dry atmosphere at the 6,000-foot elevation of RFP also causes wide temperature ranges, with strong daytime warming and nighttime cooling. High temperatures are typically in the mid-80 degrees Fahrenheit (°F) during the summer months and occasionally exceed 90 °F. The heat, however, is rarely oppressive because of low relative humidities. Even after extremely warm days, strong cooling allows temperatures to fall to 60 °F or lower during the night.

Temperatures also are relatively mild during the winter months, ranging from 40 °F to 45 °F during the day and 15 °F to 25 °F at night. Arctic and Siberian air masses occasionally bring frigid air during the winter. Low temperatures may drop to -5 °F to -12 °F or lower several times a year, while high temperatures can fail to exceed 0 °F during the coldest outbreaks.

Normal annual precipitation at RFP is nearly 15.5 inches, including rainfall and melted snow. Nearly 42 percent of the annual precipitation falls from April through June. Migratory storms often affect RFP during these months, transporting moisture from the Gulf of Mexico. Precipitation is enhanced during upslope conditions, as the air cools and becomes saturated. Precipitation falls primarily as snow from late October through early April. Arctic air masses occasionally combine with snowfall and may produce blizzard conditions. Annual snowfall averages between 70 and 75 inches, with the highest monthly snowfall (an average of 16 inches) falling in March. Summer precipitation results from showers and thundershowers. Severe thunderstorms occasionally affect areas east of the Front Range but occur infrequently at RFP. Tornadoes are unlikely to occur at RFP, although a weak tornado is theoretically possible. Drought conditions occasionally develop along the Front Range and can lead to prairie wildfires that can sometimes affect the RFP buffer zone and surrounding areas.

High wind events are common along the Front Range during the winter months. So-called "Chinook" winds are forced over and accelerate as they cross the eastern slopes of the Continental Divide. The air warms, dries

as it sinks, and compresses on the eastern side of the mountains. Chinook winds can cause ground blizzards during periods of snow cover. RFP normally experiences several days a year with peak wind gusts exceeding 60 miles per hour (mph); gusts reaching 80 mph or more occur less frequently.

The combination of fair skies, light winds, and gently sloping terrain allows local winds to form and predominate over the region. Daytime heating causes upslope winds to form, with northeasterly winds common over the broad South Platte River Valley, including RFP. More local, southeasterly winds also occasionally occur during the day at RFP because the terrain slope line is oriented along the southeast direction toward Standley Lake and the city of Arvada. The winds reverse at night, with a shallow, westerly drainage wind forming over RFP and a broad, southerly drainage wind forming over the South Platte Valley Basin. The locally produced winds are important to consider for estimating the transport and dispersion of potential pollutants in the region. The nighttime convergence of drainage winds toward the South Platte River Valley is largely responsible for Denver's "Brown Cloud."

CLIMATE SUMMARY

The meteorological monitoring program supports various operations at the RFP. Meteorological information is necessary for (1) assessing transport and diffusion characteristics of the atmosphere used in emergency response and environmental impact assessment, (2) designing other environmental monitoring networks, and (3) developing site-specific weather forecasts. Meteorological data are also used for climatological analyses, hydrological studies, and various design-base engineering studies.

The meteorological data provided in this report were taken from the 61-meter (m) tower located to the northwest of the main plantsite (Figure 3.1-1). The tower site is approximately 6,140 feet (1,870 meters) above sea level. Data recovery was approximately 99 percent for all variables during 1992, with the exception of solar radiation.

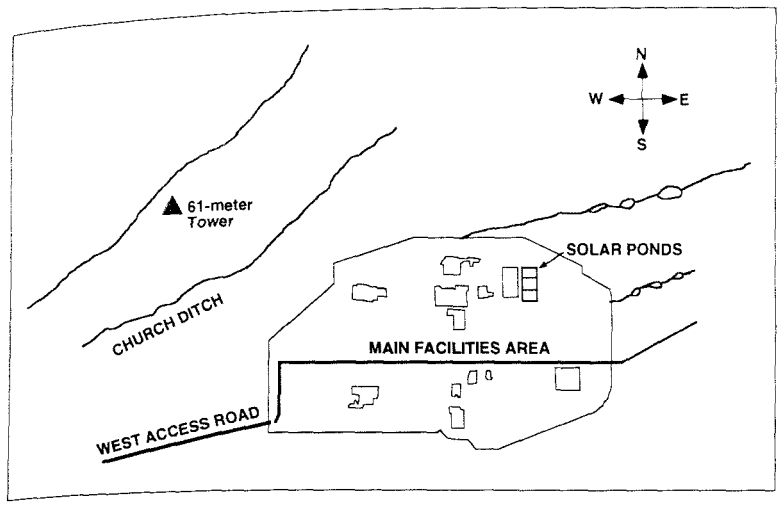
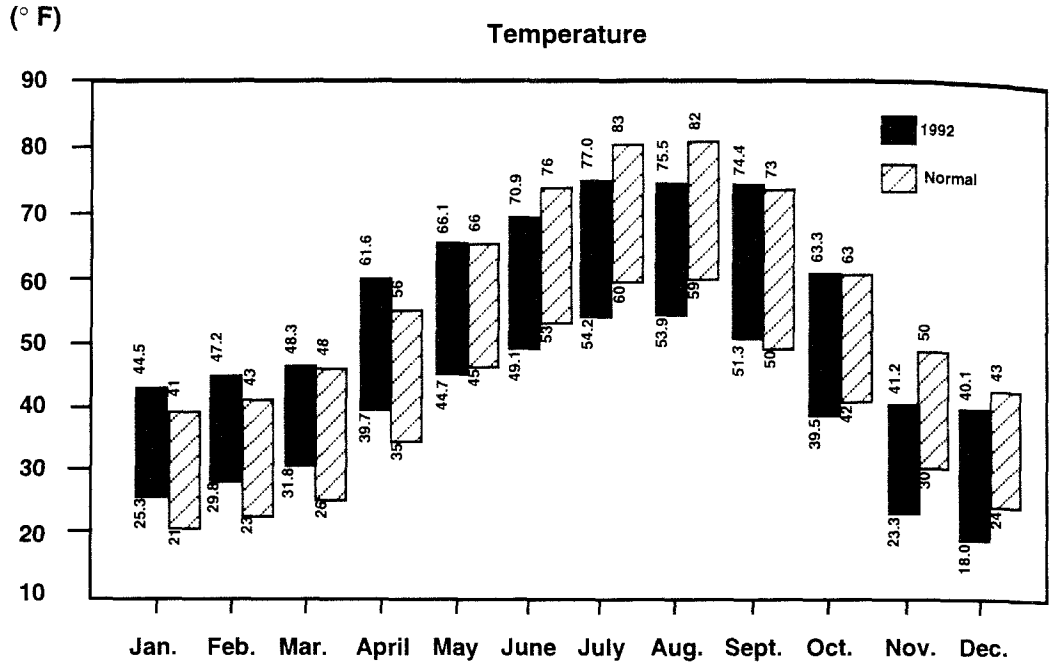


Figure 3.1-1. Location of the RFP 61-Meter Meteorological Tower

Annual climate summaries during 1992 are provided in Figure 3.1-2 and Table 3.1-1. The 1992 mean temperature of 48.8 °F was nearly 1 °F below normal. The annual temperature extremes ranged from a high of 91 °F on July 6 to a low of -4 °F on January 15. The 1992 peak wind gust of 86 mph occurred on January 24. Precipitation during the year was nearly 1 inch below normal, totaling 14.49 inches. The largest daily precipitation fell on August 24 when 1.97 inches of rain was recorded. The largest 15-minute rainfall of 0.28 inches also was recorded on this date. Monthly precipitation ranged from 3.37 inches in March to 0.00 inches in September.

The annual weather highlights included an intense snowstorm on March 8-9. The storm first produced heavy thunderstorms on March 8, followed by up to 18 inches of snow at RFP by the morning of March 9. The storm forced the closure of RFP operations not essential to maintenance of vital safety systems on March 9. Unusually warm weather occurred in April, with the month's average temperature of 50.7 °F exceeding normal temperatures by more than 5 °F. The temperature reached 82 °F on April 30. Temperatures were below normal during the months of June, July, and August; the summer of 1992 was the coolest ever recorded at RFP since record-taking began in 1953. The high temperature reached 90 °F only once during the entire summer. The low temperature plunged to 38 °F on June 1, with scattered frost reported over the Eastern Plains. The combination of the remnants of a hurricane and an unusually strong Arctic outbreak resulted in the year's largest rainfall on August 24 and 25. No precipitation was recorded during the month of September. Unusually early, severe winter weather arrived in November, with approximately 24 inches of snowfall recorded. A snowstorm on November 23 produced blizzard conditions and more than 1 foot of snow, forcing RFP to cancel operations not essential to maintenance of vital safety systems. Unusually cold temperatures persisted into December.



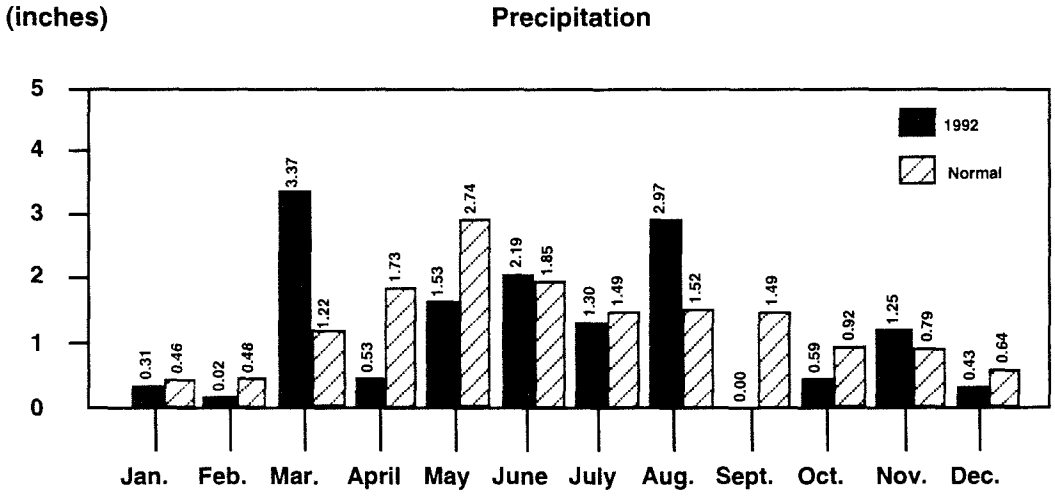


Figure 3.1-2 1992 RFP Climate Summary

Table 3.1-1

1992 Annual Climatic Summary

	Temperatures (°F)								
	Means			Extremes					
Month	High	Low	Average	High	Date	Low	Date	Mean Dew Point (°F)	Mean. Rel. Humidity (%)
January	44.5	25.3	34.9	62	31	-4	15	12.1	38
February	47.2	29.8	38.5	63	29	21	5	15.6	39
March	48.3	31.8	40.1	59	1, 2	17	10	23.1	50
April	61.6	39.7	50.7	82	30	23	1	27.2	39
May	66.1	44.7	55.4	81	1	34	27	35.2	47
June	70.9	49.1	60.0	84	30	38	1	42.6	53
July	77.0	54.2	65.6	91	6	44	2	44.1	46
August	75.5	53.9	64.7	88	9	44	26	42.2	43
September	74.4	51.3	62.8	84	12	37	18, 28	32.2	31
October	63.3	39.5	51.4	79	13	20	16	23.8	34
November	41.2	23.3	32.2	63	15	6	25	11.2	41
December	40.1	18.0	29.0	59	11	5	4	5.7	37
Annual	59.2	38.4	48.8	91	7/6	-4	1/15	26.3	41

	Wind Speed (mph)		Atmos. Pressure	Solar Total	Precipitation (inches)					Number of Days	
						Daily		15-Min.	Precip.	Max. Temp.	Min. Temp.
Month	Mean	Peak	Mean (mb)	-kW-h/m^2	Total	Max.	Date	Max.	> 0.10"	> 90°F	< 32 °F
January	10.1	86	810.3	-999	0.31	0.19	12	0.02	2	0	23
February	9.6	54	810.6	-999	0.02	0.02	23	0.01	0	0	21
March	7.8	56	809.3	-999	3.37	1.04	8	0.23	6	0	16
April	8.5	62	811.0	-999	0.53	0.21	16	0.04	3	0	7
May	7.9	45	813.7	-999	1.53	0.46	31	0.09	4	0	0
June	7.4	54	812.5	-999	2.19	0.50	19	0.24	6	0	0
July	7.7	56	816.0	-999	1.30	0.23	25	0.21	6	1	0
August	7.3	42	818.1	-999	2.97	1.97	24	0.28	6	0	0
September	9.0	56	815.2	-999	0.00	-	-	-	0	0	0
October	7.4	49	813.9	109.6	0.59	0.40	25	0.08	1	0	9
November	8.4	56	809.7	71.4	1.25	0.45	23	0.05	3	0	26
December	9.1	71	807.2	65.4	0.43	0.12	3	0.01	2	0	29
Annual	8.4	86	812.3	-999	14.49	1.97	8/24	0.28	39	1	131

The annual summary of wind direction and speed frequencies measured at the 10-m height are provided in Table 3.1-2 and are shown graphically by a wind rose in Figure 3.1-3. Compass point designations indicate the direction from which the wind blew (wind along each vector blows toward the center). Wind directions most frequently are from the west-southwest through northerly directions. Wind speeds above 18 mph (8 meters per second [m/s]) occur primarily with westerly winds and, to a lesser extent, northerly winds.

Table 3.1-2

RFP Wind Direction Frequency (Percent) by Four Wind-Speed Classes

(15 - Minute Averages - Annual 1992)

	Calm	<1.0 m/s (<2.2 mph)	1.0 - 2.5 m/s (2.2 - 5.6 mph)	2.5 - 4.0 m/s (5.6 - 9.0 mph)	4.0 - 8.0 m/s) (9.0 - 18 mph)	>8.0 m/s (> 18 mph)	Total
	1.69						1.69
N	-	-	2.13	2.69	2.70	0.24	7.75
NNE	-	-	1.96	2.04	1.75	0.16	5.91
NE	-	-	1.66	1.70	0.78	0.09	4.23
ENE	-	-	1.49	1.23	0.42	0.01	3.16
E	-	-	1.94	1.17	0.21	0.00	3.32
ESE	-	-	1.94	1.59	0.20	0.00	3.73
SE	-	-	1.96	2.20	0.82	0.00	4.98
SSE	-	-	1.84	2.21	1.19	0.03	5.26
S	-	-	1.95	2.03	1.15	0.01	5.14
SSW	-	-	1.78	2.07	0.92	0.02	4.79
SW	-	-	1.90	2.56	1.70	0.05	6.20
WSW	-	-	1.91	2.72	2.74	0.30	7.67
W	-	-	2.53	2.37	2.24	1.28	8.42
WNW	-	-	2.63	2.03	3.95	2.86	11.47
NW	-	-	2.47	2.53	2.93	0.85	8.78
NNW	-	-	2.09	2.79	2.48	0.14	7.50
TOTALS	1.69	-	32.18	33.92	26.17	6.04	100.00

The change in winds is illustrated in Figures 3.1-4 and 3.1-5. Day is defined as the period between 1 hour after sunrise to 1 hour before sunset. Night is defined as the remainder of the time. Locally and regionally produced, thermally driven winds are apparent during the day, with northeasterly up-valley and southeasterly upslope winds. Locally produced winds usually have wind speeds of 11 mph (5 m/s) or less. Stronger, larger-scale winds occur from the west and, to a lesser extent, northerly directions.

The distribution of nighttime winds is nearly reversed, with Rocky Flats drainage winds causing a high frequency of westerly winds. The South Platte Valley drainage also contributes to the high frequency of southwesterly winds. The distribution of stronger winds indicating larger scale winds is similar to the daytime. There is a scarcity of easterly winds at night.

Pasquill-Gifford stability classes are used to estimate horizontal and vertical dispersion and are input into atmospheric dispersion models. Stability classes at RFP were estimated using the sigma theta technique, where the stability is determined from the standard deviation of horizontal wind, mean horizontal wind

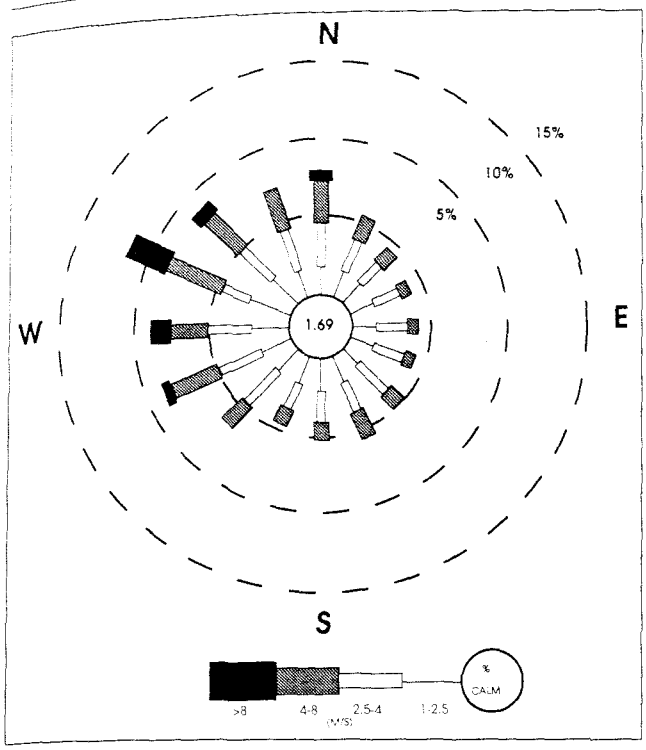


Figure 3.1-3. RFP 1992 Wind Rose - 24-Hour

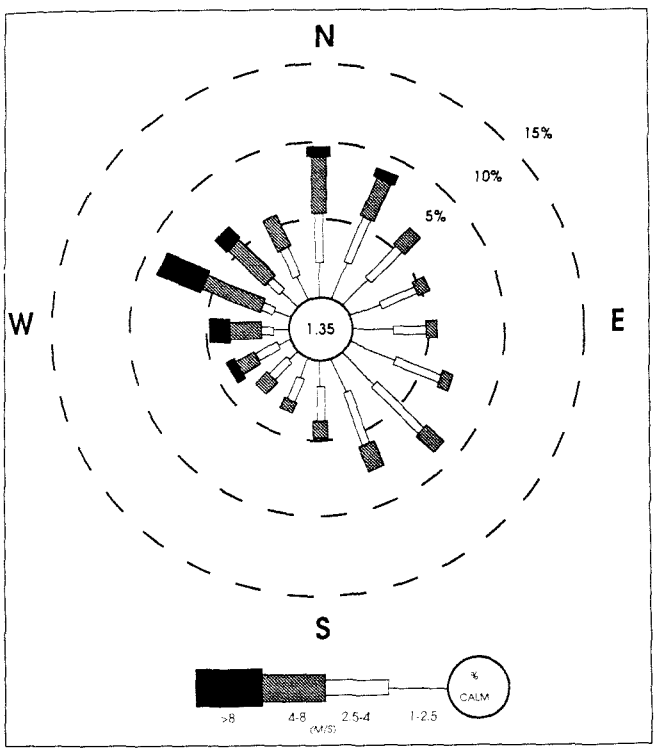


Figure 3.1-4. RFP 1992 Wind Rose - Day

speed, and whether day or night (EPA86). Another EPA-recommended technique, the sigma phi method, results in an unrealistically high number of neutral and stable cases, thereby underestimating RFP dispersion and generally overestimating atmospheric concentrations resulting from potential releases. The stability classes range from A to F, or extremely unstable to very stable, respectively. The D class represents neutral stability. By definition, daytime stability ranges from A to D and nighttime stability ranges from D to F. The stability category is defined as D whenever the wind speed equals or exceeds 6 m/s (13.4 mph). The 1992 percent occurrence of winds by stability class is shown in Table 3.1-3.

Results show that unstable categories (A through C) occur 25 percent of the time, and stable categories (E through F) occur 32.5 percent of the time. Neutral stability occurs most frequently, more than 42 percent of the time. Frequency distributions of wind speed direction for each stability category are presented in Appendix C. The speed classes (knots) follow the guidelines for the STAR (Stability Array) deck used as input for various regulatory dispersion models. Calms were distributed according to STAR deck procedures.

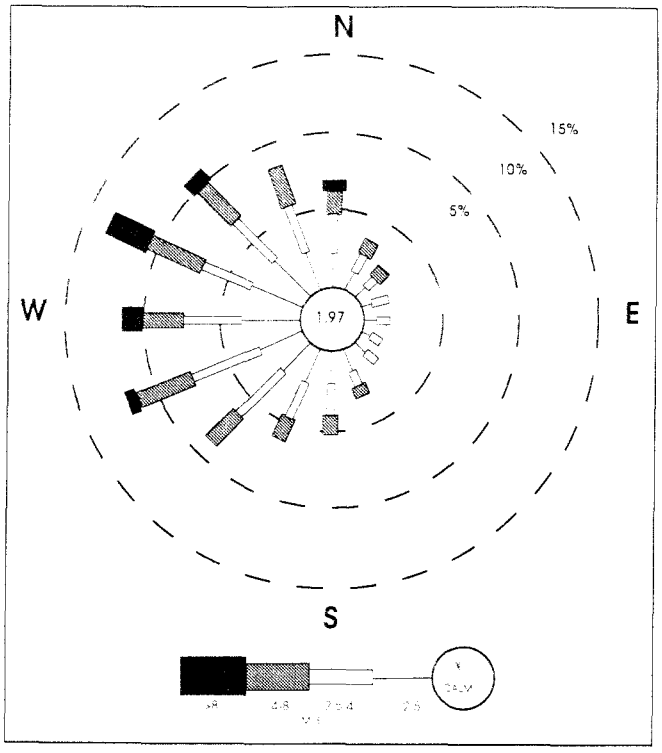


Figure 3.1-5. RFP 1992 Wind Rose - Night

Table 3.1-3

Percent Occurrence of Winds by Stability Class

Stability Class	Percent Occurrence
A	9.9
B	7.1
C	8.1
D	42.4
E	21.0
F	11.5

3. Environmental Monitoring Programs

3.2 Air Monitoring

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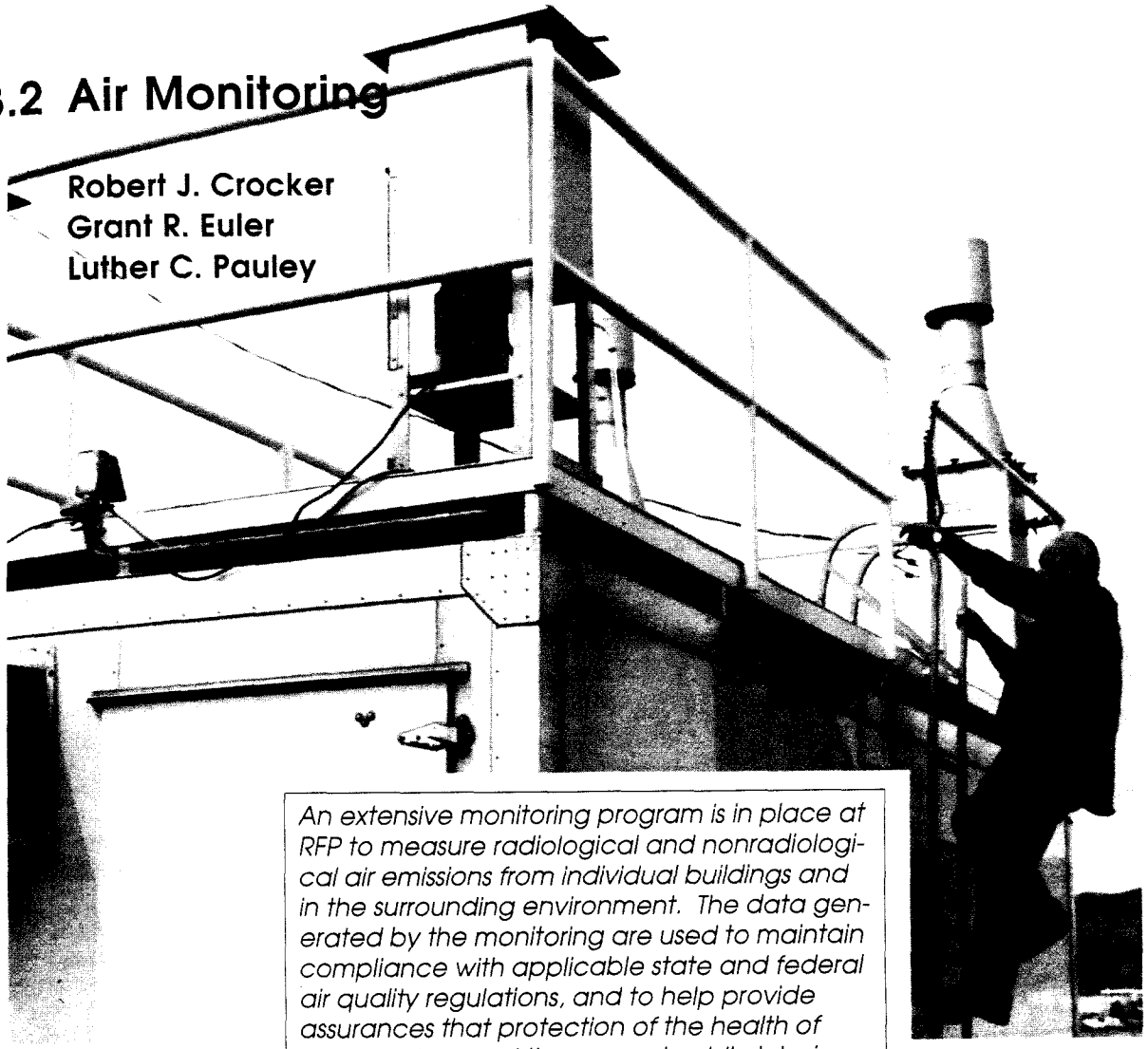


An extensive monitoring program is in place at RFP to measure radiological and nonradiological air emissions from individual buildings and in the surrounding environment. The data generated by the monitoring are used to maintain compliance with applicable state and federal air quality regulations, and to help provide assurances that protection of the health of plant workers and the general public is being maintained. This section provides the results of monitoring from effluent air, and from radioactive and nonradioactive ambient air.

EFFLUENT AIR MONITORING

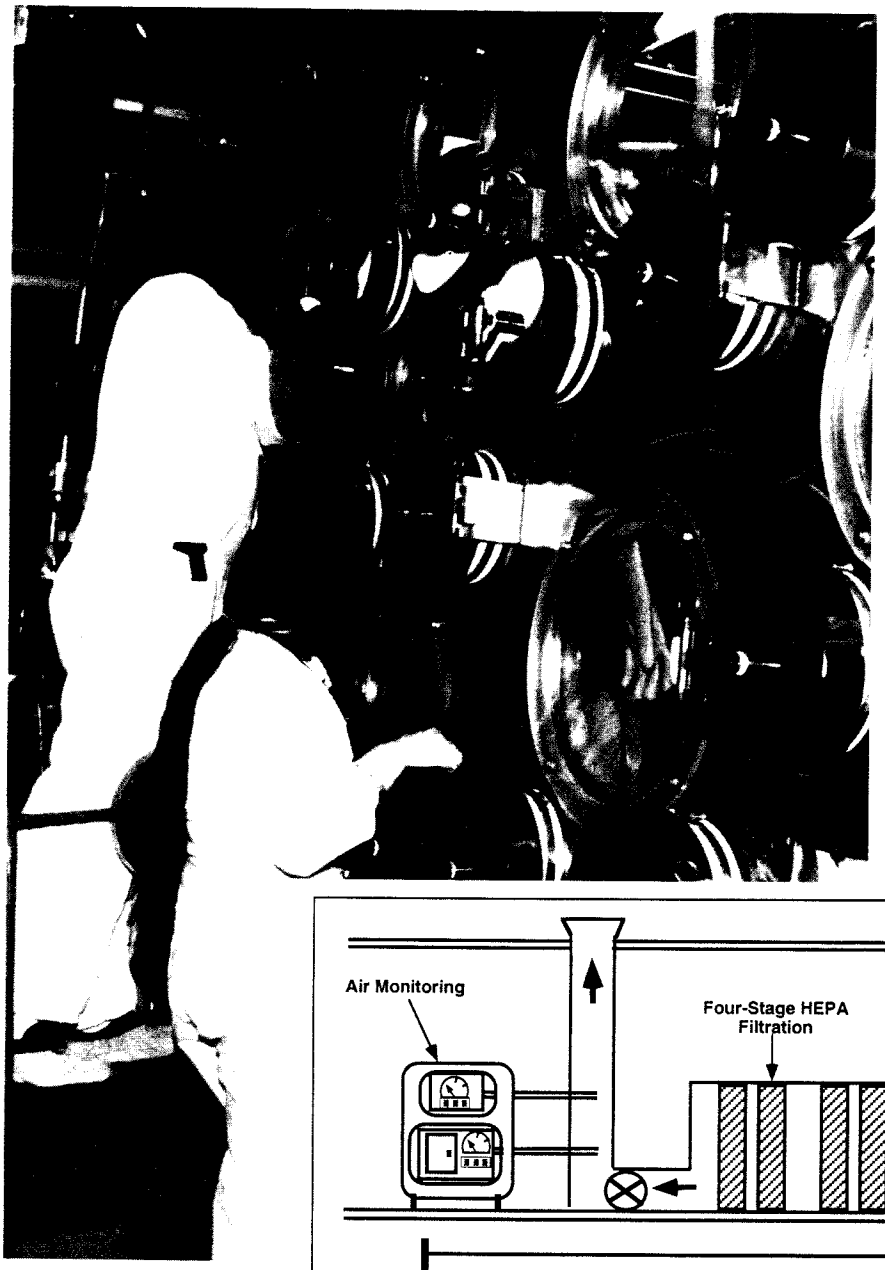
Overview

The term "effluent" refers to something that flows out into the environment. An effluent could be a stream flowing out of a lake or other body of water. It also can refer to the release of air to the environment. At RFP, effluent refers to air emissions released to the environment from processing and laboratory facilities, and to the release of water (liquid effluents), particularly surface-water runoff and treated sanitary wastewater. (Liquid effluents are discussed further in Section 3.3, Surface-Water Monitoring.)

At RFP, several protective measures and controls are in place to minimize any releases of radioactive or hazardous material to the environment. The air effluent control program actually begins in specially constructed buildings where radioactive materials are handled. These buildings house ventilation and filtration systems that constantly filter the air, while monitoring equipment measures building emissions to the environment.

Air pressure in the buildings is controlled to prevent any unplanned release of material to the environment. Passage through a series of airlocks, with decreasing air pressure, is required to reach interior areas of buildings where plutonium and other radioactive materials are handled inside glovebox systems. Air pressure in the glovebox system is lower than the air pressure in the buildings, which, in turn, is less than the outside air pressure. The system was designed so that if a leak were to develop in a glovebox, the radioactive material would not be allowed to escape; it would instead be contained in the glovebox and filtered for radioactive particulates (see Figure 3.2-1). In addition to isolating radioactive material from the environment, gloveboxes serve to protect employees from unnecessary exposure to radiation.

Plutonium, uranium, and americium, the primary radioactive materials used and handled at RFP, are in a solid particle form. As a result, particle filtration of the airborne effluent streams is an important and effective means of controlling the release of these materials to the environment. Radioactive particles generated by RFP activities enter exhaust air streams that are attached to the glovebox system where the particulate materials are removed by highly efficient filters. These



Sealed glovebox systems are used at RFP to isolate radioactive materials from the environment and protect employees from unnecessary exposure to radiation.

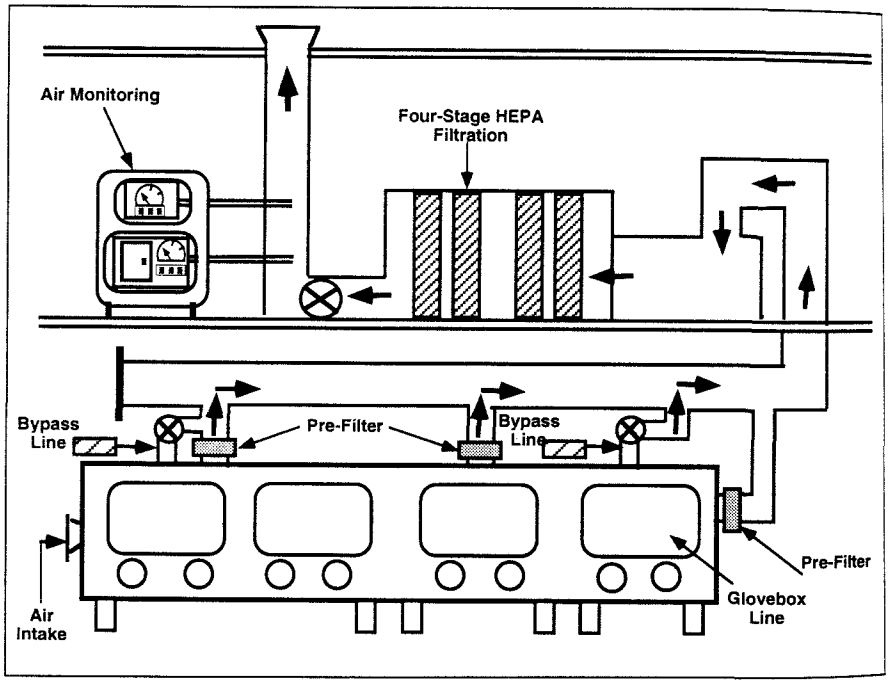


Figure 3.2-1. Glovebox Ventilation/Filtration Exhaust System

High Efficiency Particulate Air (HEPA) filters, referred to as absolute filters in the electronics industry, must meet strict construction and performance criteria before they are accepted for use at RFP.

HEPA filters are designed to be fire- and chemical-resistant. They are constructed of tiny glass fibers combined with a small amount of organic material added for strength and water repellency. Upon arrival at the plant, HEPA filters are tested to ensure a minimum efficiency of 99.97 percent for all particle sizes. After installation, the filters are tested again to guard against any damage during installation and to ensure proper seating in the filter's housing.

Multiple banks of HEPA filters, called filter plenums, are installed in series in air exhaust systems (see Figure 3.2-2). In general, plutonium processing exhaust systems are equipped with four to six stages of HEPA filter banks, while uranium processing exhaust systems are equipped with a minimum of two stages of filter banks. These filter banks, combined with other protective measures, help ensure that airborne releases of radioactive material from RFP are minimal and do not pose any significant health risk to the public or the environment. (Building air not associated with the glovebox system and processing operations is controlled, filtered, and monitored before it is released to the environment.)

RFP continuously monitors radionuclide air emissions at 63 locations in 17 buildings. The radiological particulate monitoring and sampling program uses a three-tier approach, comprising Selective Alpha Air Monitors (SAAMs), total long-lived alpha screening of routine air duct emission sample filters, and radiochemical analysis of isotopes collected for air duct emission samples. This approach balances both sensitivity and timeliness of results.

For immediate detection of abnormal conditions, RFP building ventilation systems that service areas containing plutonium are equipped with SAAMs. SAAMs are sensitive to specific alpha particle energies and are set to detect plutonium-239 and -240. These detectors are subjected to daily operational checks, monthly performance testing and calibration for airflow, and an annual radioactive source calibration to maintain sensitivity

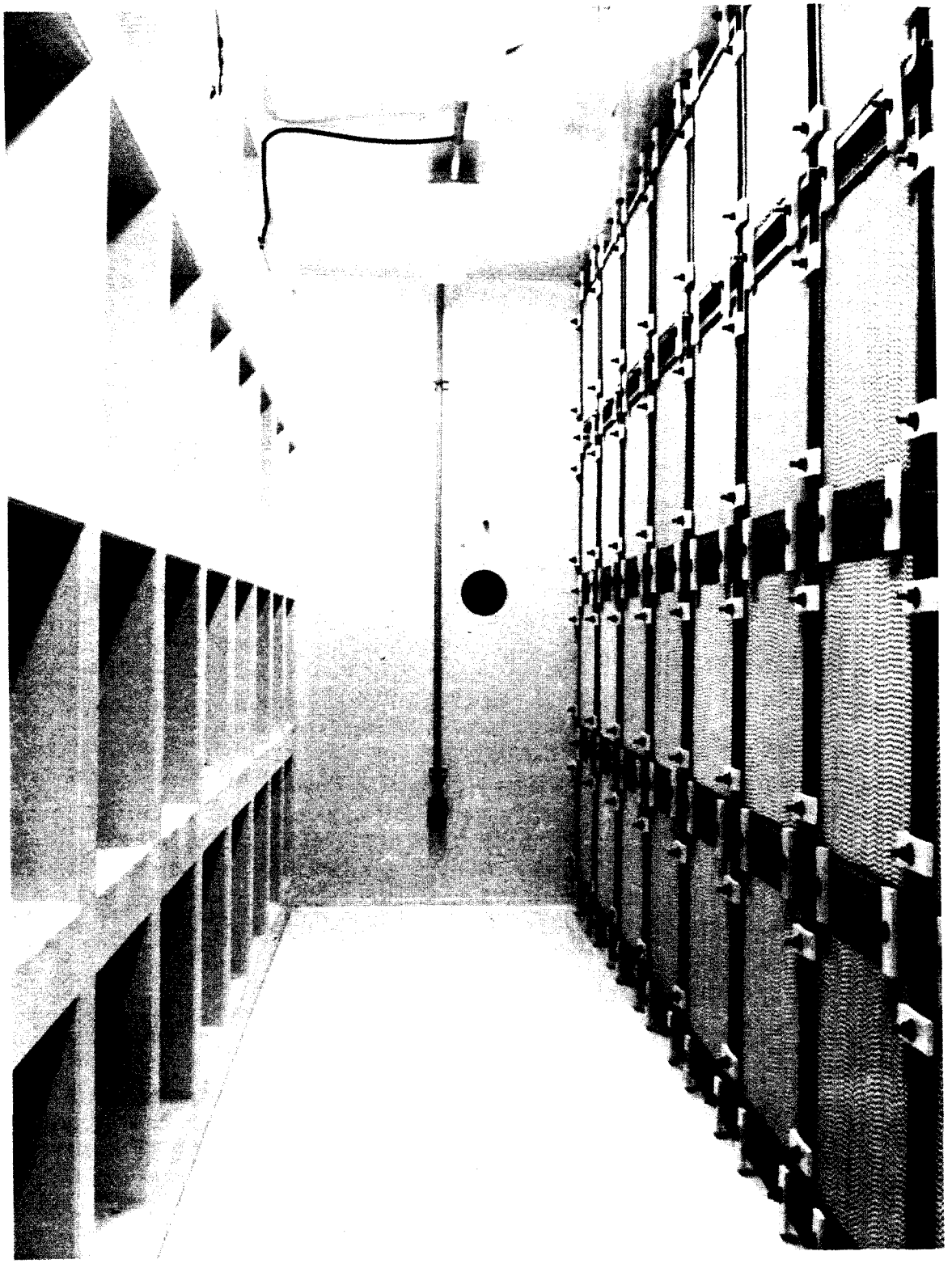


Figure 3.2-2. High Efficiency Particulate Air Filter Banks

and reliability (see Figure 3.2-3). Monitors alarm automatically if any out-of-tolerance conditions are detected. No such condition occurred during 1992.

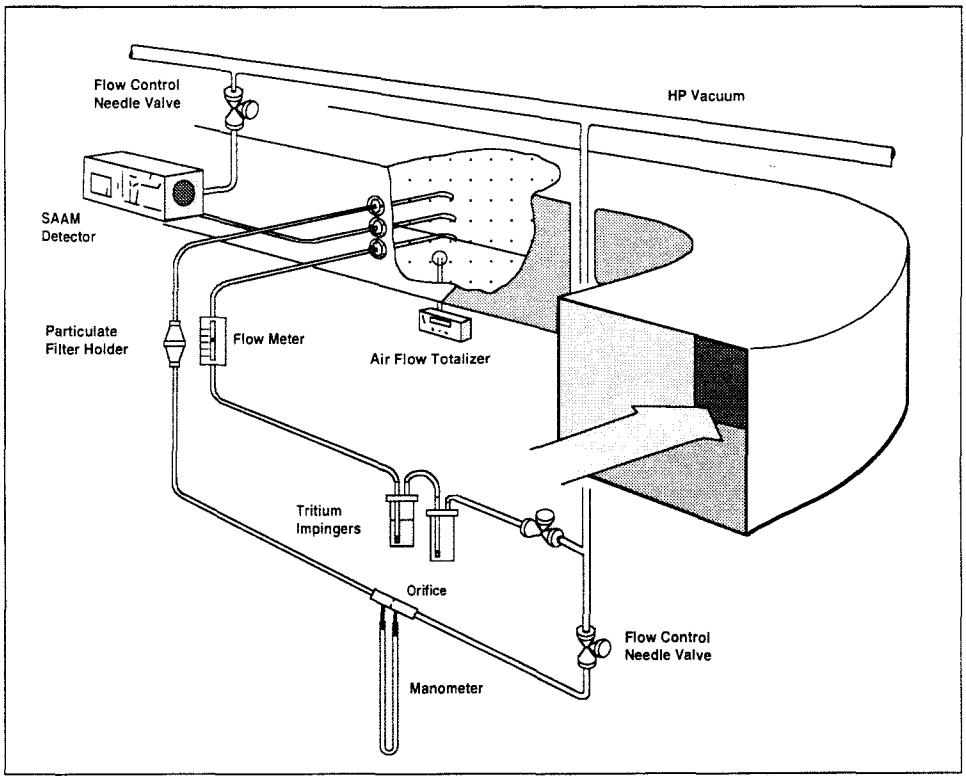
At regular intervals, particulate material samples from the continuous sampling systems are removed from the exhaust systems and radiometrically analyzed for long-lived alpha emitters. The concentration of long-lived alpha emitters is indicative of effluent quality and overall performance of the HEPA filtration system. If the total long-lived alpha concentration for an effluent sample exceeds the RFP action value of 0.020×10^{-12} microcuries per milliliter ($\mu Ci/ml$) (7.4×10^{-4} Becquerels per cubic meter [Bq/m^3]), a follow-up investigation is conducted to determine the cause and to evaluate the need for corrective action. The action guide value is equal to the most restrictive offsite Derived Concentration Guide (DCG) for plutonium activity in air. (See Appendix B for an explanation of the action guide.)

At the end of each month, individual samples from each exhaust system are composited into larger samples by location. A portion of each dissolved composite sample is analyzed for beryllium particulate materials. The remainder of the dissolved sample is subjected to radiochemical separation and alpha spectral analysis, which quantifies specific alpha-emitting radionuclides. Analyses for uranium isotopes are conducted for each composite sample.

Forty-one of the ventilation exhaust systems are located in buildings where plutonium processing is conducted. Particulate material samples from these exhaust systems are analyzed for specific isotopes of plutonium and americium. Typically, americium contributes only a small fraction of the total alpha activity release from RFP. Processes that are ventilated from several exhaust systems potentially exhibit trace quantities of tritium contamination. Bubble-type samplers are used to collect samples three times each week from the monitored locations. Tritium concentrations in the sample are measured using a liquid scintillation photospectrometer.

Results

Projected doses to the public from radionuclide emissions were within the NESHAP limits of 10 mrem/year EDE. A discussion of radiation dose estimates from air emissions is included in Section 6, "Radiation Dose Assessment."



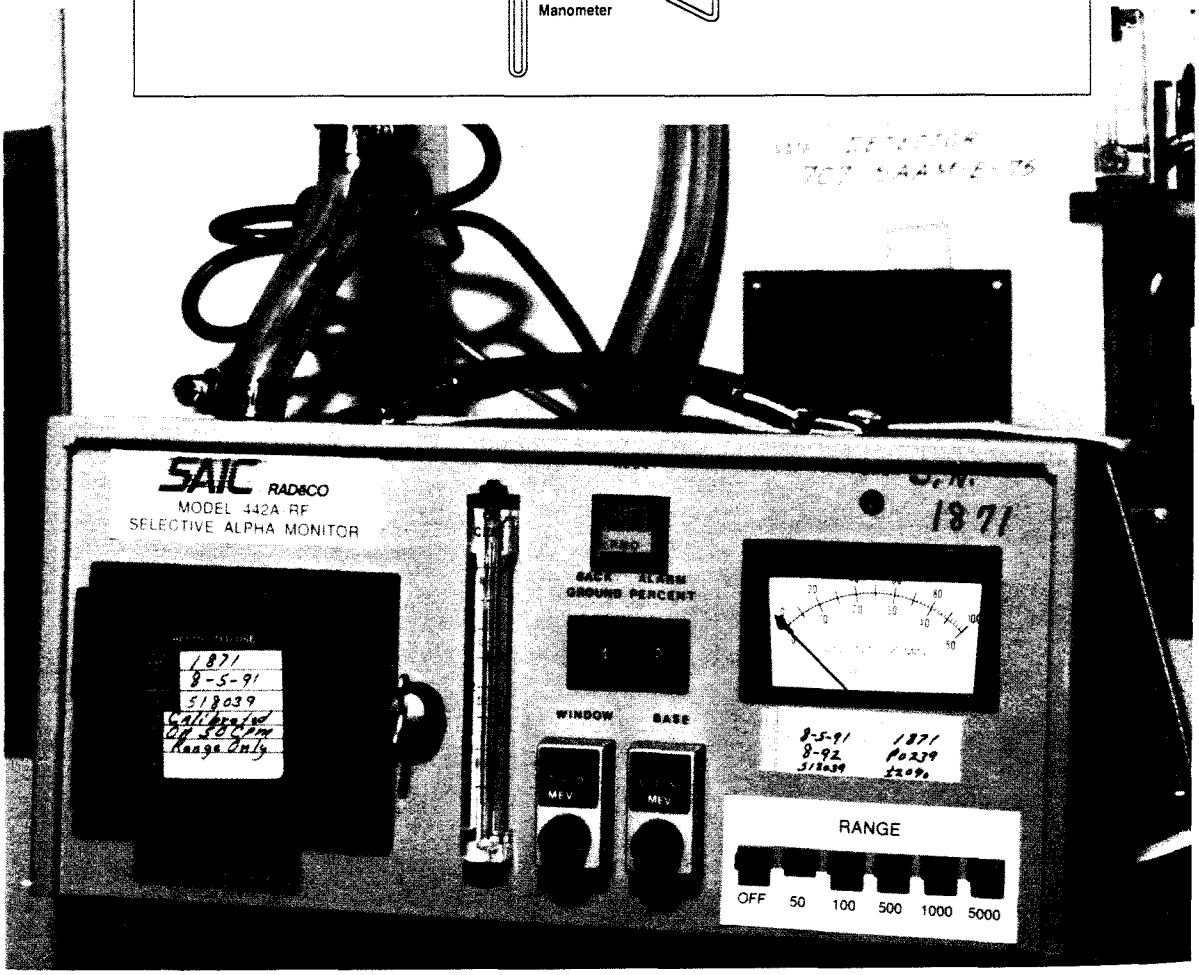


Figure 3.2-3. Radiological Effluent Air Sampling System (top)
Selective Alpha Air Monitor (bottom)

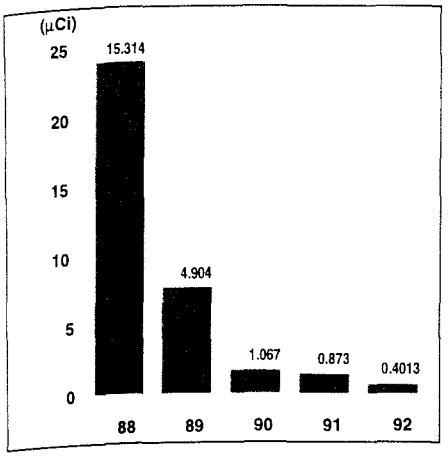


Figure 3.2-4. Plutonium-239, -240

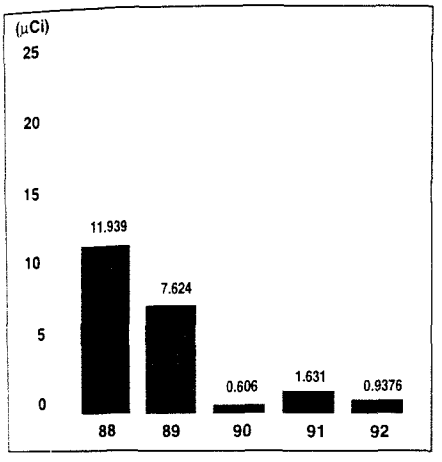


Figure 3.2-5. Uranium-233, -234, -238

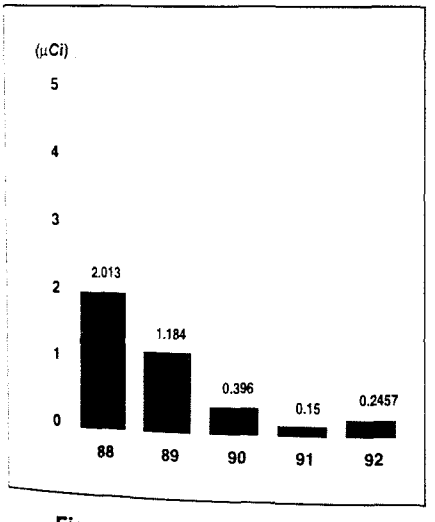


Figure 3.2-6. Americium-241

Plutonium and Uranium. During 1992, total quantities of plutonium and uranium discharged to the atmosphere from RFP processing and support buildings were 0.4013 μCi (1.48 x 10^4 Bq) and 0.9376 μCi (3.47 x 10^4 Bq), respectively (Tables 3.2-1 and 3.2-2). These values were corrected for background radiation. Annual plutonium-239, -240 and uranium-233, -234, -238 emissions for the 1988 to 1992 period are provided in Figures 3.2-4 and 3.2-5, respectively.

The overall decrease in radionuclide emissions since 1988 is a reflection of reduced production activities at RFP that resulted when plutonium production operations were curtailed in late 1989. Many of these operations have not resumed because of the subsequent cancellation of new weapons systems and the change in plant mission from a production-oriented mission to a new mission focusing on environmental restoration and decontamination of facilities.

Values reported for total quantities of plutonium and uranium discharges for 1992 may vary from the monthly environmental monitoring reports because of rounding in calculations and because the annual report includes plutonium-238, -239, and -240. Plutonium -238 represents 4.3 percent of the total plutonium discharged in 1992.

Americium. Total americium discharged in 1992 was 0.2457 μCi (9.09 x 10^3 Bq) (Table 3.2-3). The maximum concentration was 0.00125 x 10^{-12} μCi/ml, observed in samples taken in December. Americium values were corrected for background radiation. Annual americium emissions for the period 1988 to 1992 are provided in Figure 3.2-6.

Tritium. Total tritium discharged during 1992 from ventilation systems in which tritium is routinely measured was 0.0038 Ci (1.41 x 10^8 Bq) (Table 3.2-4). The maximum tritium concentration of 117 x 10^{-12} μCi/ml (4.33 Bq/m^3) was observed during October from routine operations in an RFP plutonium facility. Each month is divided into a series of individual sampling periods. The sum of the discharges for these sampling periods is the total tritium discharge for the month. Tritium values include a small, unquantified contribution attributed to natural background sources (i.e., non-plant sources). Annual measured tritium emissions for the period 1988 to 1992 are provided in

Figure 3.2-7. In addition, Buildings 123, 881, and 374 have low-level tritium emissions for which monitoring is not performed. These emissions are estimated using emission factors as provided in 40 CFR 61. The total of the measured and estimated tritium emissions also is provided in Table 3.2-4.

Beryllium. The total quantity of beryllium discharged from ventilation exhaust systems was 3.399 g. The maximum concentration was 0.00066 $\mu g/m^3$ observed in March. These values were not significantly above background levels associated with the analyses. The beryllium stationary-source emission standard is 10 g during a 24-hour period. Table 3.2-5 presents the beryllium airborne effluent data for 1992.

The total quantity of beryllium discharged during 1992 varies from the monthly environmental monitoring reports. The annual report includes values for all 49 exhaust systems while the monthly report provides discharges for six exhaust systems on buildings where beryllium is processed. Beryllium discharges are monitored monthly at the remaining 43 locations, but are only provided in monthly reports if they exceed a screening level of 0.1 g. Annual beryllium emission for the period 1988 to 1992 are shown in Figure 3.2-8. RFP ceased using analytical blanks in laboratory analysis to correct sample beryllium concentrations in September 1989. As a result, reported beryllium values measure both background and actual emission levels.

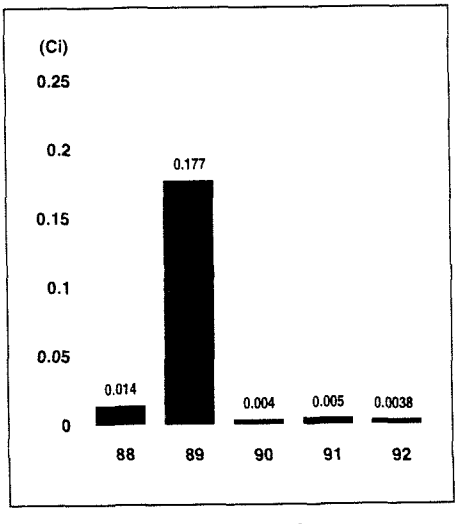


Figure 3.2-7. Tritium

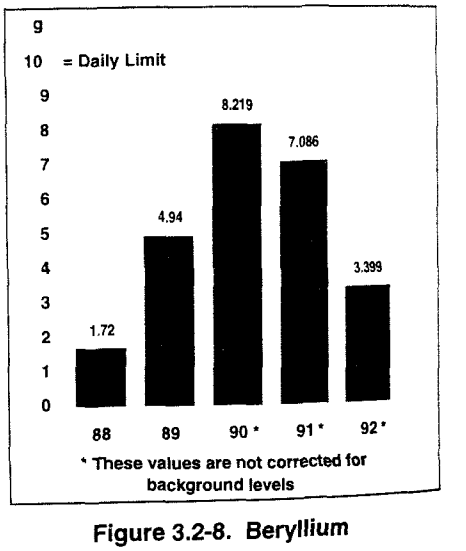


Figure 3.2-8. Beryllium

Table 3.2-1
Plutonium in Effluent Air

Month	Number of Analyses	Plutonium-238 Total Discharge (µCi)	Plutonium-238 C maximum[a] (x 10^{-12} µCi/ml)	Plutonium-239,-240 Total Discharge (µCi)	Plutonium-239,-240 C maximum[a] (x 10^{-12} µCi/ml)
January	46	0.0021 ± 0.0019	0.0000 ± 0.0000	0.0320 ± 0.0045	0.0002 ± 0.0001
February	45	-0.0006 ± 0.0017	0.0000 ± 0.0000	0.0225 ± 0.0037	0.0001 ± 0.0000
March	45	0.0011 ± 0.0014	0.0000 ± 0.0000	0.0330 ± 0.0051	0.0002 ± 0.0001
April	45	0.0013 ± 0.0014	0.0000 ± 0.0001	0.0182 ± 0.0031	0.0001 ± 0.0000
May	42	0.0007 ± 0.0016	0.0000 ± 0.0000	0.0249 ± 0.0039	0.0002 ± 0.0001
June	44	0.0034 ± 0.0014	0.0000 ± 0.0000	0.0839 ± 0.0109	0.0014 ± 0.0002
July	46	0.0011 ± 0.0012	0.0000 ± 0.0000	0.0135 ± 0.0029	0.0003 ± 0.0001
August	41	0.0010 ± 0.0012	0.0000 ± 0.0000	0.0204 ± 0.0036	0.0001 ± 0.0000
September	46	0.0017 ± 0.0011	0.0000 ± 0.0000	0.0429 ± 0.0042	0.0013 ± 0.0002
October	46	0.0008 ± 0.0013	0.0000 ± 0.0000	0.0256 ± 0.0034	0.0001 ± 0.0000
November	46	0.0010 ± 0.0013	0.0000 ± 0.0000	0.0168 ± 0.0036	0.0001 ± 0.0000
December	46	0.0004 ± 0.0022	0.0000 ± 0.0000	0.0503 ± 0.0063	0.0016 ± 0.0003
Overall	538	0.0173[b,c] ± 0.0177	0.0000 ± 0.0000	0.3841[b,c] ± 0.0552	0.0016 ± 0.0003

a. Maximum sample concentration.
b. Minor discrepancies in total discharge values result from rounding errors in calculations.
c. One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

Table 3.2-2
Uranium in Effluent Air

Month	Number of Analyses	Uranium-233, -234 Total Discharge (µCi)	Uranium-233, -234 C maximum[a] (x 10^{-12} µCi/ml)	Uranium-238 Total Discharge (µCi)	Uranium-238 C maximum[a] (x 10^{-12} µCi/ml)
January	54	-0.0059 ± 0.0073	0.0001 ± 0.0000	0.0294 ± 0.0081	0.0001 ± 0.0000
February	53	0.0299 ± 0.0089	0.0001 ± 0.0000	0.0737 ± 0.0096	0.0004 ± 0.0001
March	53	0.0294 ± 0.0088	0.0001 ± 0.0000	0.0642 ± 0.0094	0.0007 ± 0.0002
April	53	0.0264 ± 0.0092	0.0000 ± 0.0000	0.0504 ± 0.0095	0.0001 ± 0.0000
May	50	0.0115 ± 0.0086	0.0000 ± 0.0000	0.0474 ± 0.0089	0.0001 ± 0.0000
June	52	0.0057 ± 0.0076	0.0001 ± 0.0000	0.0321 ± 0.0082	0.0001 ± 0.0000
July	54	0.0031 ± 0.0080	0.0000 ± 0.0000	0.0171 ± 0.0083	0.0003 ± 0.0001
August	49	0.0103 ± 0.0115	0.0001 ± 0.0000	0.0323 ± 0.0124	0.0001 ± 0.0001
September	54	0.0314 ± 0.0103	0.0004 ± 0.0001	0.0989 ± 0.0175	0.0023 ± 0.0005
October	54	0.0468 ± 0.0083	0.0001 ± 0.0000	0.0663 ± 0.0090	0.0002 ± 0.0001
November	54	0.0710 ± 0.0087	0.0036 ± 0.0006	0.0469 ± 0.0067	0.0001 ± 0.0000
December	54	0.0784 ± 0.0106	0.0041 ± 0.0006	0.0410 ± 0.0084	0.0002 ± 0.0001
Overall	634	0.3380[b,c] ± 0.1078	0.0041 ± 0.0006	0.5996[b,c] ± 0.1160	0.0023 ± 0.0005

a. Maximum sample concentration.
b. Minor discrepancies in total discharge values result from rounding errors in calculations.
c. One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

Table 3.2-3
Americium in Effluent Air

		Americium-241		
Month	Number of Analyses	Total Discharge (μCi)		C maximum [a] ($\times 10^{-12}$ μCi/ml)
January	46	0.0078 ± 0.0033		0.0003 ± 0.0001
February	45	0.0088 ± 0.0030		0.0003 ± 0.0001
March	45	0.0143 ± 0.0029		0.0012 ± 0.0002
April	45	0.0070 ± 0.0026		0.0001 ± 0.0000
May	42	0.0198 ± 0.0037		0.0001 ± 0.0000
June	44	0.1069 ± 0.0141		0.0010 ± 0.0002
July	46	0.0054 ± 0.0030		0.0001 ± 0.0000
August	41	0.0084 ± 0.0027		0.0000 ± 0.0000
September	46	0.0147 ± 0.0028		0.0008 ± 0.0001
October	46	0.0096 ± 0.0034		0.0001 ± 0.0000
November	46	0.0169 ± 0.0038		0.0001 ± 0.0000
December	46	0.0261 ± 0.0039		0.0012 ± 0.0002
Overall	538	0.2457[b,c] ± 0.0493		0.0012 ± 0.0002

a. Maximum sample concentration.
b. Minor discrepancies in total discharge values result from rounding errors in calculations.
c. One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

Table 3.2-4
Tritium in Effluent Air

	Tritium		
Month	Number of Analyses	Total Discharge (Ci)	C maximum[a] ($\times 10^{-12}$ μCi/ml)
January	78	0.00073	34 ± 9
February	72	0.00057	41 ± 14
March	55	0.00039	39 ± 7
April	71	0.00001	23 ± 5
May	62	0.00015	24 ± 7
June	61	0.00026	22 ± 7
July	51	0.00013	27 ± 4
August	14	0.00017	36 ± 5
September	70	0.00037	38 ± 16
October	78	0.00006	117 ± 11
November	77	0.00068	80 ± 7
December	78	0.00026	67 ± 10
Measured Emissions	767	0.00380[b]	117 ± 11
Estimated Emissions		0.083[c]	
Total Measured and Estimated		0.0868	

a. Maximum sample concentration.
b. Minor discrepancies in total discharge values result from rounding errors in calculations.
c. Buildings 123, 881, and 374 have low-level tritium emissions for which monitoring is not performed. These emissions are estimated using emission factors as provided in 40 CFR 61 for determination of compliance with CAA NESHAP requirements.

Table 3.2-5
Beryllium in Effluent Air

Month	Number of Analyses	Beryllium[a,b] Total Discharge[c] (g)			C maximum[d] (µg/m^3)
January	54	0.2559	±	0.0077	0.00047
February	53	0.2590	±	0.0076	0.00035
March	53	0.3540	±	0.0099	0.00066
April	53	0.3749	±	0.0112	0.00052
May	50	0.4285	±	0.0128	0.00039
June	52	0.3012	±	0.0097	0.00031
July	54	0.1948	±	0.0055	0.00044
August	49	0.1231[e]	±	0.0035	0.00031
September	54	0.2877	±	0.0091	0.00032
October	54	0.2727	±	0.0080	0.00030
November	54	0.3074	±	0.0090	0.00046
December	54	0.2397	±	0.0073	0.00037
Overall	634	3.3990	±	0.1013	0.00066

a. The beryllium stationary source is no more than 10 grams of beryllium over a 24-hour period under the provisions of subpart C of 40 CFR 61.32(a).
b. Beginning in June 1989, concentrations and emission values were not corrected for background contribution.
c. These values are not significantly different from the background associated with the analysis.
d. Maximum sample concentration.
e. One value only contributing to this total was based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

NONRADIOACTIVE AMBIENT AIR MONITORING

Overview

In addition to effluent sampling from individual buildings, RFP also performs monitoring of ambient air in the surrounding environment. This includes sampling for nonradioactive particulates as well as radioactive materials. (Results of the radioactive ambient air monitoring program are provided in the following section.)

Nonradioactive ambient air monitoring was conducted in 1992 for total suspended particulates (TSPs) and respirable particulates (less than or equal to 10 micrometers [µm]) in diameter. Ambient particulates are regulated by the EPA and CDH under the CAA and its amendments, as defined by the National Ambient Air Quality Standards (NAAQS) and Colorado Air Quality Control Commission Ambient Air Standards. Regulation is based on regional rather than site-specific air quality parameters. In the past, EPA particulate standards (NAAQS) were based on TSP, a measure of total

particulate recovery, regardless of particulate size. The present EPA standards, referred to as Particulate Matter-10 (PM-10), are based on respirable particulates, those particles less than or equal to 10 μm in diameter. Final EPA respirable particulate standards were issued on July 1, 1987 (EPA87a), and reference methods were issued on October 6 and December 1, 1987. PM-10 samplers at RFP were procured to meet EPA design specifications.

Results

Nonradioactive ambient air monitoring is performed in an area near the east entrance to RFP and provides baseline information on particulate levels. Table 3.2-6 identifies sampling equipment used for measuring particulates. TSP and PM-10 samplers are collocated at the monitoring site. The location is unobscured by structures, is near a traffic zone, and is generally downwind from plant facilities. Samplers are operated on an EPA sampling schedule of 1 day per every 6th day. TSP is measured by the EPA-referenced, high-volume air sampling method, and continues to be collected for reference purposes. Interruptions associated with the electrical service to this location limited sample collection during the second half of 1992.

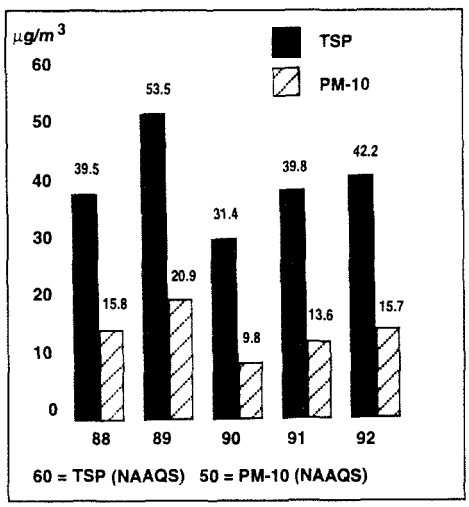


Figure 3.2-9. TSP and PM-10

Particulate data are provided in Table 3.2-7. (Current PM-10 and former TSP NAAQS standards are provided in Appendix B.) The highest TSP value recorded in 1992 (24-hour sample) was 106.2 micrograms per cubic meter (μg/m^3), which was 41 percent of the former TSP 24-hour primary standard. The annual geometric mean value was 47.6 μg/m^3, which was 79 percent of the former TSP primary annual geometric mean standard. The observed 24-hour maximum for the PM-10 sampler was 47.3 μg/m^3 (31.5 percent of the primary 24-hour standard), and the annual arithmetic mean was 14.7 μg/m^3 (29 percent of the primary annual arithmetic mean standard). Mean annual concentrations of particulates for onsite ambient TSP samplers and PM-10 samplers for the period 1988 to 1992 are shown in Figure 3.2-9.

Table 3.2-6
Ambient Air Monitoring Detection Methods

Parameter	Detection Methods
Particulate Matter less than 10 micrometers in diameter (PM-10)	Wedding PM-10 Sampler 24-Hour sampling (6th-day scheduling)
Total Suspended Particulates (TSP)	Reference Method (Hi Volume) 24-Hour sampling (6th-day scheduling)

Table 3.2-7
Ambient Air Quality Data for Nonradioactive Particulates

Total Suspended Particulates

	Total No. of Samples	Annual Geometric Mean ($\mu g/m^3$)	Standard Deviation ($\mu g/m^3$)	Observed 24-hr Max. ($\mu g/m^3$)	Second Highest Max. ($\mu g/m^3$)	Lowest Observed Value ($\mu g/m^3$)
Primary Ambient Air TSP Particulate Sampler; Primary Unit	29	42.2	20.0	94.5	92.2	21.6
Collocated Duplicate TSP Sampler	28	47.6	20.9	106.2	85.7	21.3

Respirable Particulates (PM-10)

	Total No. of Samples	Annual Arithmetic Mean ($\mu g/m^3$)	Observed 24-hr Max. ($\mu g/m^3$)	Second Highest Max. ($\mu g/m^3$)
Primary Ambient Air PM-10 Sampler	30	14.7	47.3	22.6
Collocated Duplicate PM-10 Sampler	23	15.7	44.4	22.2

RADIOACTIVE AMBIENT AIR MONITORING

Overview

Ambient air samplers located on the plantsite, at the plant perimeter, and in surrounding communities monitor airborne dispersion of radioactive materials from RFP into the surrounding environment. These samplers are positioned at 23 locations on the plantsite, at 14 locations around the plant boundary, and in 11 neighboring communities. Figure 3.2-10 illustrates the locations of plantsite samplers and samplers located at the plant boundary. Community ambient air samplers are illustrated in Figure 3.2-11. The CDH also maintains an independent sampling network with a different instrument design in and around the plantsite to verify the RFP data.

The high-volume air samplers operate continuously at a volumetric flow rate of approximately 12 liters per second (l/s) (25 cubic feet per minute [ft^3/min]), collecting air particulates on highly efficient 20- by 25-centimeter (8- by 10-inch) fiberglass filters. Manufacturer's test specifications rate this filter media to be 99.97 percent efficient for relevant particle sizes under conditions typically encountered in routine ambient air sampling (SC82).

Ambient air filters are collected biweekly and composited monthly by location before isotopic analysis. All routine ambient air filters are analyzed for plutonium -239 and -240.

Results

Plutonium concentrations for onsite samplers are provided in Table 3.2-8. Plutonium concentrations for perimeter and community samplers are provided in Table 3.2-9. Overall mean plutonium concentration for onsite samplers was 0.099×10^{-15} µCi/ml (3.66×10^{-6} Bq/m^3), 0.49 percent of the offsite DCG for plutonium in air (Appendix B). Overall mean plutonium concentration for perimeter samplers was 0.002×10^{-15} µCi/ml (5.5×10^{-8} Bq/m^3), which is 0.008 percent of the offsite DCG for plutonium in air. Overall mean plutonium concentration for community samplers was 0.001×10^{-15} µCi/ml (3.7×10^{-8} Bq/m^3), or 0.006 percent of the offsite DCG for plutonium in air.

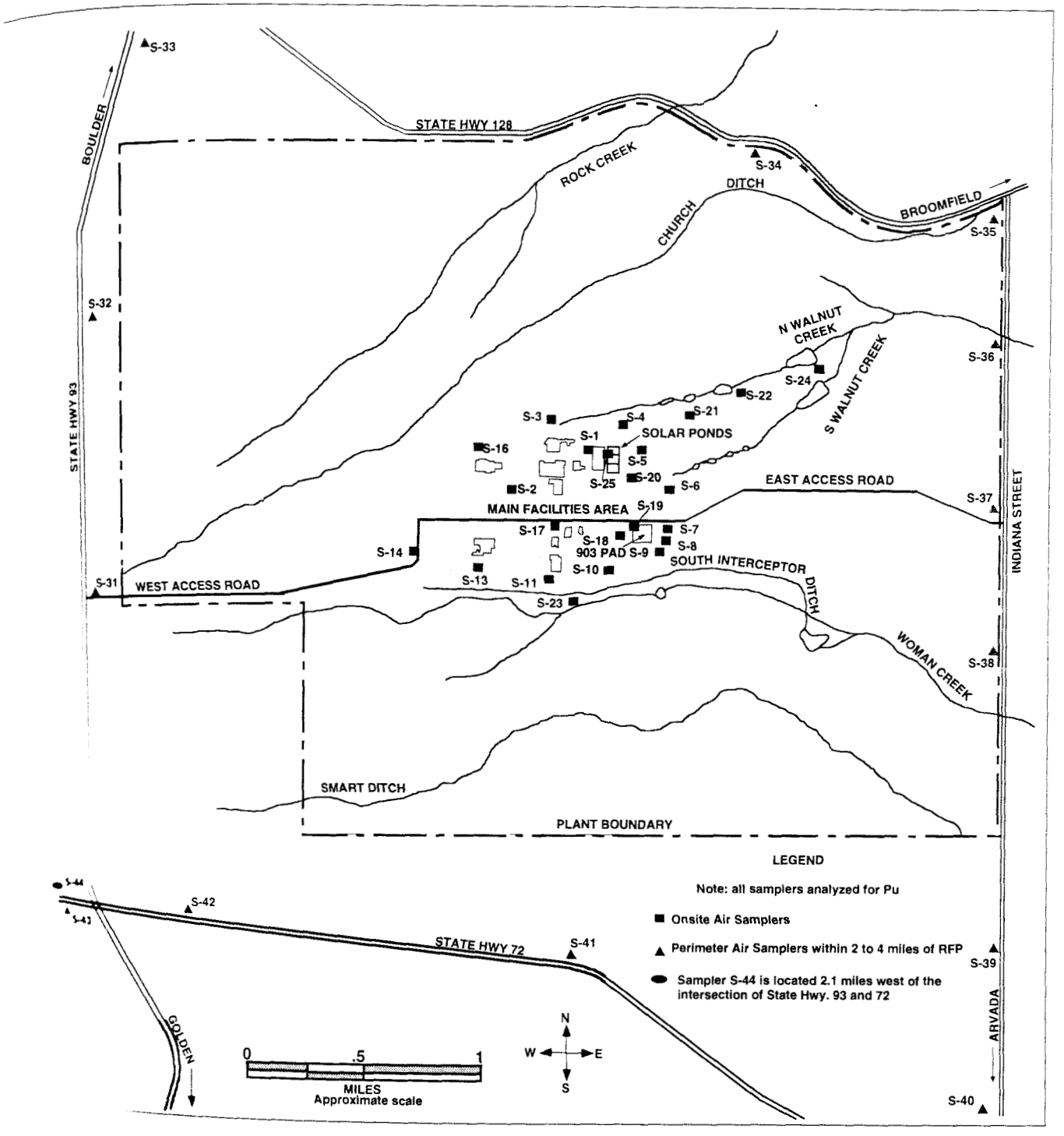


Figure 3.2-10. Onsite and Perimeter Ambient Air Samplers

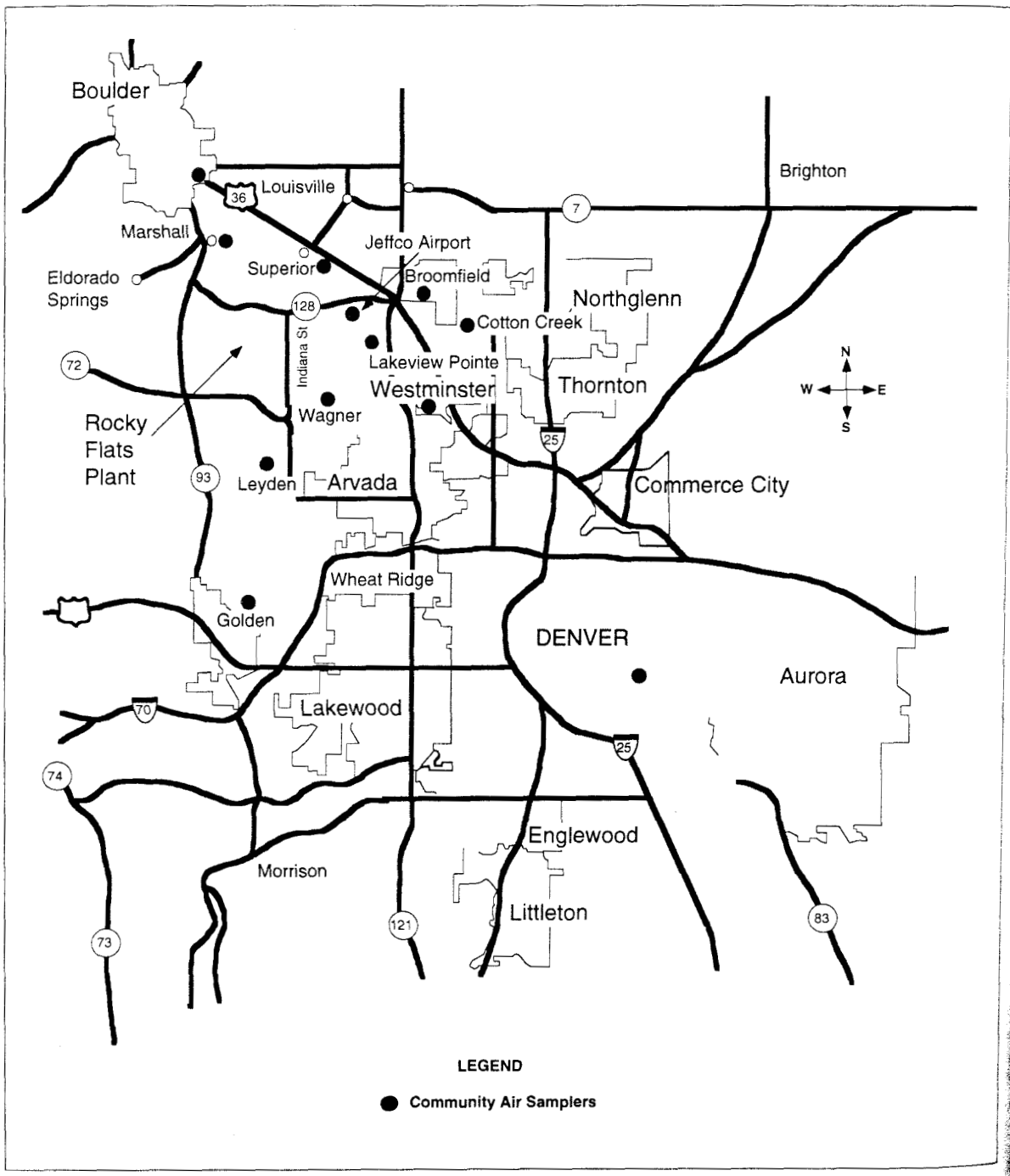


Figure 3.2-11. Community Ambient Air Samplers

Table 3.2-8

Onsite Ambient Air Sampler Plutonium Concentrations[a,b]

Station	Number of Samples	Concentration (x 10^{-15} µCi/ml)[c] C minimum	C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[d] (C mean)
S-1	7	.18300	2.27700	.57843	.75667	2.89214
S-2	9	.00100	.09200	.01478	.02946	.07389
S-3	10	.00000	.01200	.00430	.00403	.02150
S-4	3	.00200	.01000	.00633	.00404	.03167
S-5	12	.00700	.04900	.02683	.01475	.13417
S-6	12	.00100	2.12600	.24933	.59619	1.24667
S-7	12	.00000	1.00200	.19367	.26793	.96833
S-8	11	.06800	1.29000	.49882	.44614	2.49409
S-9	12	.03500	2.14900	.55117	.61495	2.75583
S-10	11	.00100	.02300	.00727	.00618	.03636
S-11	12	.00100	.01200	.00658	.00365	.03292
S-13	12	.00100	.00400	.00267	.00107	.01333
S-14	12	.00000	.00200	.00083	.00083	.00417
S-16	12	-.00100	.00300	.00175	.00114	.00875
S-17	12	.00300	.01600	.00850	.00458	.04250
S-18	12	.00400	.03600	.01775	.00962	.08875
S-19	12	.00400	.11000	.03292	.03192	.16458
S-20	11	.00500	.09300	.01718	.02535	.08591
S-21	9	.00200	.01400	.00633	.00415	.03167
S-22	12	.00100	.01200	.00642	.00363	.03208
S-23	11	.00000	.00800	.00355	.00311	.01773
S-24	8	.00100	.00500	.00363	.00160	.01813
S-25	9	.02800	.15100	.07500	.04631	.37500
Overall	243	-.00100	2.27700	.09869	.30131	.49344

a. Some locations are calculated using less than 12 months of data because of mechanical malfunctions, incomplete laboratory analyses, or removal of a sampler (S-4).
b. Isotope-specific analyses were reported only for locations S-5 through S-9 before 1990 (see Figure 3.2-12). These five samplers are the only onsite locations included in the 5-year trending portion of this report.
c. Concentrations reflect monthly composites of biweekly station concentrations; C minimum = minimum composited concentration; C maximum = maximum composited concentration; C mean = mean composited concentration.
d. The DOE Derived Concentration Guide (DCG) for inhalation of class W plutonium by members of the public is 20 x 10^{-15} µCi/ml (Appendix B). Protection standards for members of the public are applicable for offsite locations. All locations in this table are on RFP property. DCGs for the public are presented here for comparison purposes only.

Table 3.2-9

Perimeter Ambient Air Sampler Plutonium Concentrations[a]

Station	Number of Samples	Concentration (x 10^{-15} µCi/ml)[b] C minimum	C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[c] (C mean)
S-31	11	.00000	.00200	.00073	.00065	.00364
S-32	11	-.00100	.00200	.00045	.00093	.00227
S-33	10	.00000	.00300	.00070	.00095	.00350
S-34	11	.00000	.00300	.00073	.00090	.00364
S-35	11	.00000	.00400	.00100	.00134	.00500
S-36	11	.00000	.00300	.00109	.00094	.00545
S-37	11	.00000	.00600	.00236	.00175	.01182
S-38	11	.00000	.00400	.00164	.00112	.00818
S-39	11	.00000	.00300	.00091	.00122	.00455
S-40	12	.00000	.07100	.00683	.02023	.03417
S-41	12	.00000	.00400	.00092	.00124	.00458
S-42	12	.00000	.00900	.00167	.00264	.00833
S-43	10	.00000	.00300	.00097	.00110	.00450
S-44	11	.00000	.00200	.00055	.00069	.00273
Overall	155	-.00100	.07100	.00150	.00577	.00752

Community Ambient Air Sampler Plutonium Concentrations[a]

Station	Community Name	Number of Samples	Concentration (x 10^{-15} µCi/ml)[b] C minimum	C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[c] (C mean)
S-51	Marshall	11	.00000	.00200	.00082	.00075	.00409
S-52	Jeffco Airport	12	.00000	.00400	.00167	.00150	.00833
S-53	Superior	11	.00000	.00600	.00127	.00185	.00636
S-54	Boulder	12	.00000	.00400	.00108	.00138	.00542
S-56	Broomfield	12	.00000	.00200	.00058	.00067	.00292
S-58	Wagner	12	.00000	.00600	.00150	.00173	.00750
S-59	Leyden	12	.00000	.00300	.00083	.00111	.00417
S-60	Westminster	12	.00000	.01100	.00200	.00295	.01000
S-62	Golden	12	.00000	.00400	.00092	.00116	.00458
S-68	Lakeview Pointe	12	.00000	.01000	.00225	.00280	.01125
S-73	Cotton Creek	9	.00000	.00200	.00100	.00087	.00500
Overall		127	.00000	.01100	.00128	.00172	.00638

a. Some locations are calculated using less than 12 months of data because of mechanical malfunctions or incomplete laboratory analyses.
b. Concentrations reflect monthly composites of biweekly station concentrations; C minimum = minimum composited concentration; C maximum = maximum composited concentration; C mean = mean composited concentration.
c. The DOE Derived Concentration Guide (DCG) for inhalation of class W plutonium by members of the public is 20 x 10^{-15} µCi/ml (Appendix B). Protection standards for members of the public are applicable for offsite locations and are based on calculated radiation dose.

Mean annual concentrations of plutonium for the 1988 to 1992 period are shown in Figure 3.2-12 (onsite samplers) and Figure 3.2-13 (perimeter and community samplers). The onsite data are based on the mean of the annual concentrations from five locations, S-5 through S-9, which represent the areas where the highest concentrations would most likely be observed. Isotope-specific analyses were not reported for other onsite locations until 1990. The perimeter data points are the annual averages of 14 locations, and the community data points are the annual average of 11 locations.

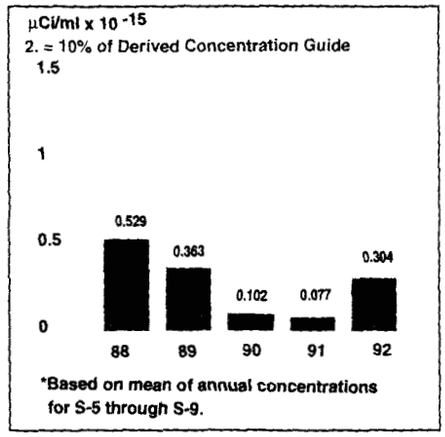


Figure 3.2-12. Plutonium-239, -240 (Onsite Samplers)

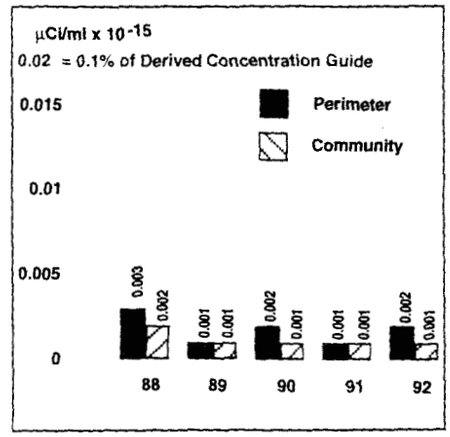
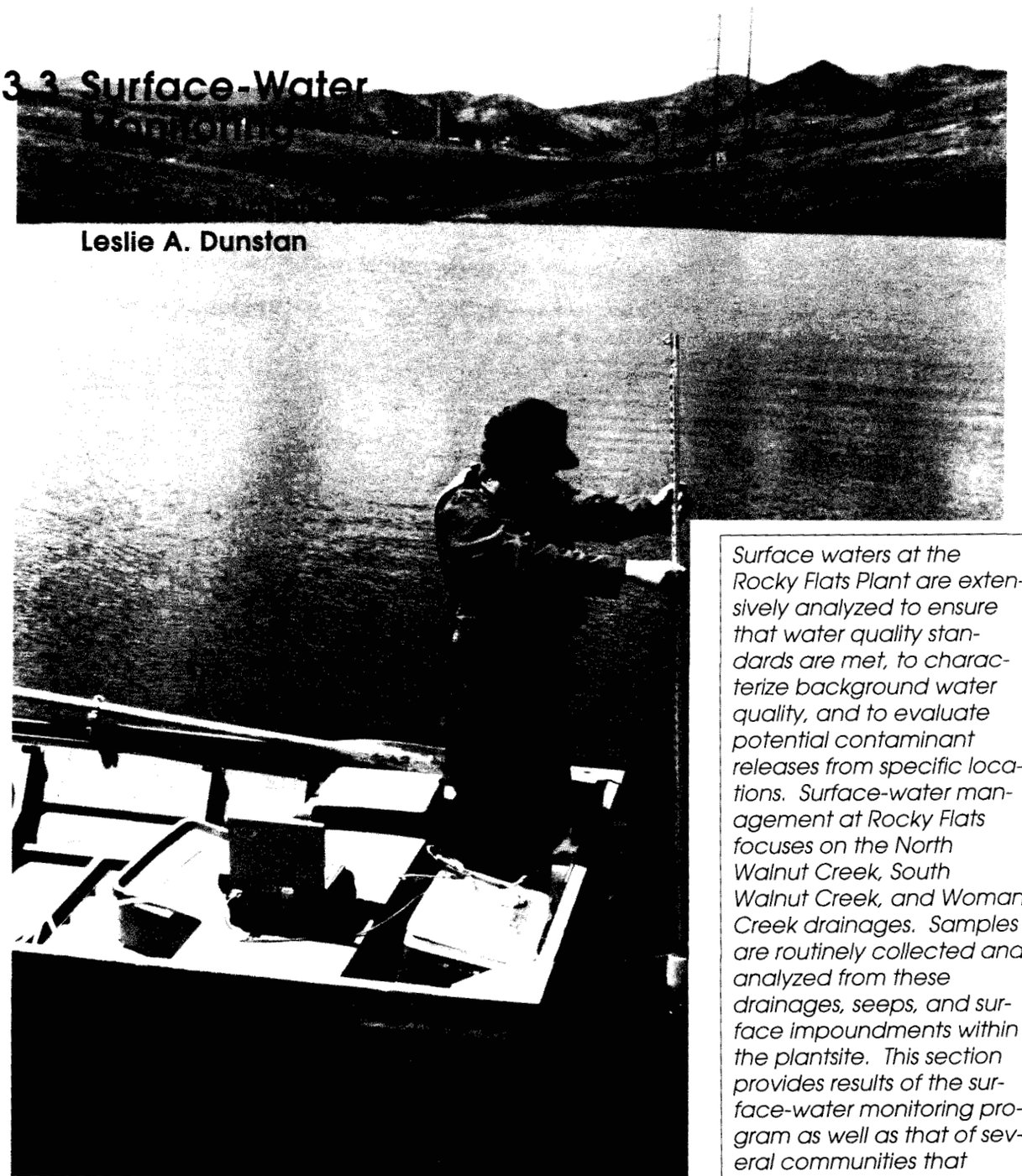


Figure 3.2-13. Plutonium-239, -240 (Perimeter and Community Samplers)

3. Environmental Monitoring Programs

3.3 Surface-Water Monitoring

Leslie A. Dunstan



Surface waters at the Rocky Flats Plant are extensively analyzed to ensure that water quality standards are met, to characterize background water quality, and to evaluate potential contaminant releases from specific locations. Surface-water management at Rocky Flats focuses on the North Walnut Creek, South Walnut Creek, and Woman Creek drainages. Samples are routinely collected and analyzed from these drainages, seeps, and surface impoundments within the plantsite. This section provides results of the surface-water monitoring program as well as that of several communities that surround the plantsite.

OVERVIEW

Liquid effluents originating from RFP are carefully controlled and monitored as part of the plant's environmental protection program. Two types of liquid effluents, treated sanitary water and surface-water runoff, are collected, controlled, and monitored in a series of ponds before discharge offsite. Surface runoff at RFP moves from west to east and is carried from the plant by three major drainage basins: North Walnut Creek, South Walnut Creek, and Woman Creek.

DRAINAGE SYSTEMS

North Walnut Creek

North Walnut Creek receives surface-water runoff and some seepage water from the northern portion of the main facilities area and from the adjacent grounds associated with the drainage. The drainage area associated with North Walnut Creek includes the north portion of plantsite from First Street at Sage Avenue to Pond A-4 and encompasses approximately 378 acres (Figure 3.3-1). The length of North Walnut Creek from the West Interceptor Ditch to the outfall of Pond A-4 is approximately 10,500 feet. Ponds A-1 and A-2 are isolated from Walnut Creek at the A-1 bypass. The gate valves at the A-1 bypass have the capability to divert the North Walnut Creek stream flow by way of an underground pipeline to Ponds A-3 or A-4. Ponds A-1 and A-2 are maintained for emergency spill control for the northern portion of the main facility. Under routine circumstances, the water comprising Pond A-2 is direct precipitation, minimal runoff, or water transferred from Ponds A-1, B-1, and B-2. Pond A-2 volume is maintained by spray evaporation; fog nozzles direct the spray over the surface of the ponds. Pond A-3 on North Walnut Creek is used to impound the surface runoff for water quality analysis prior to discharge to Pond A-4 and subsequent release offsite to the Broomfield Diversion Ditch. Pond A-4 is located downstream of Pond A-3 on North Walnut Creek and provides the capability for additional water quality monitoring, additional detention capacity during storm or flood conditions, and water treatment if required. The volumetric capacity of Pond A-1 is 1.40 million gallons; Pond A-2, 6.0 million gallons; Pond A-3, 12.37 million gallons; and Pond A-4, 32.50 million gallons.

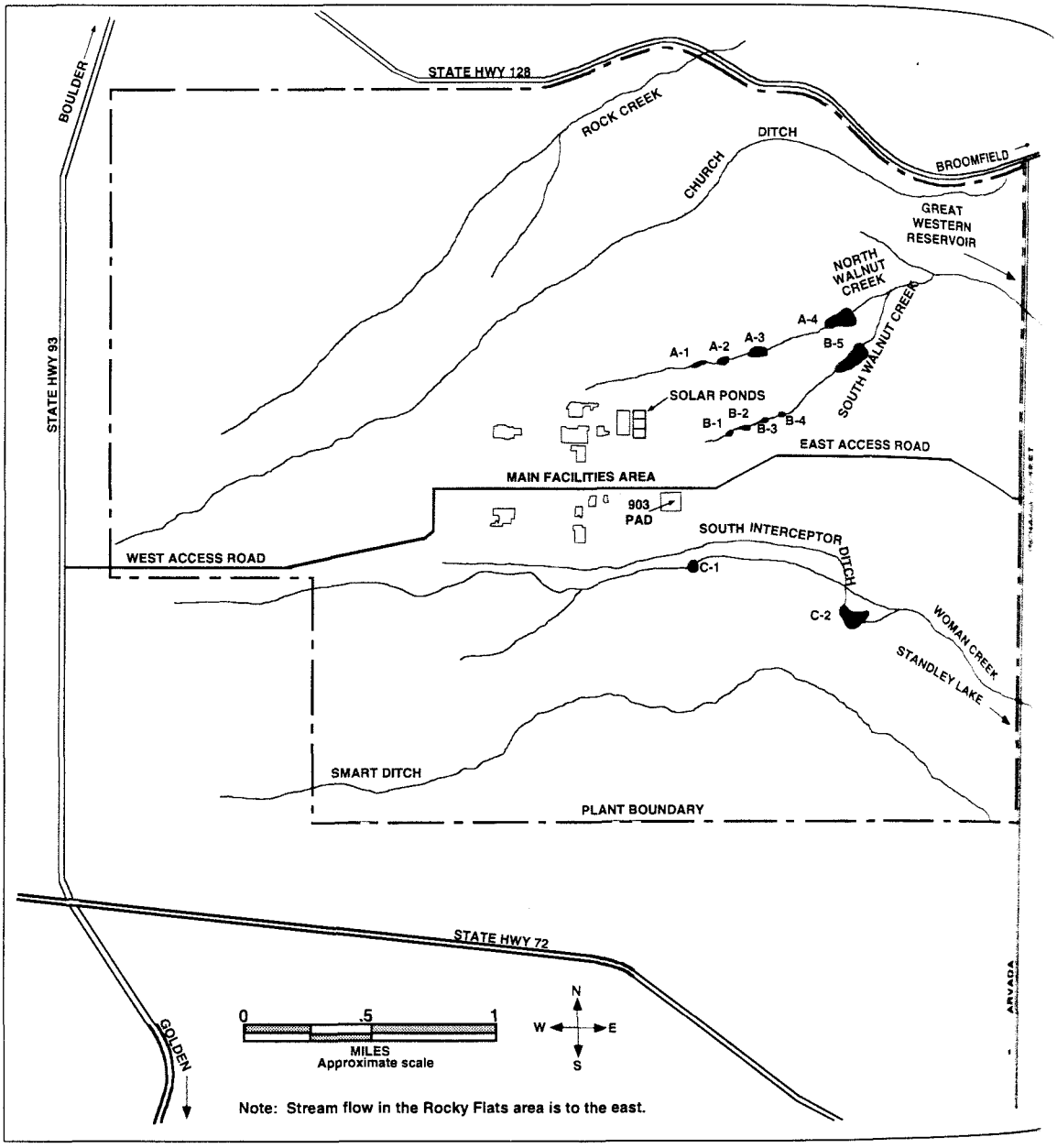


Figure 3.3-1. Holding Ponds and Liquid Effluent Water Courses

South Walnut Creek

South Walnut Creek receives surface-water runoff and some seepage water from the central portion of the main facilities area and from the adjacent grounds associated with the drainage. The drainage area associated with this portion of South Walnut Creek extends from RFP's First Street to Pond B-5 and is approximately 338 acres (Figure 3.3-1). The length of South Walnut Creek from Building 131 at First Street to Pond B-5 is approximately 9,625 feet. Ponds B-1 and B-2 are isolated from South Walnut Creek at the B-1 bypass. Ponds B-1 and B-2 are maintained for emergency spill control for the central portion of the main facility. In the event of a spill emergency, the gate valves at the B-1 bypass have the capability of diverting South Walnut Creek flows to Pond B-1, and succeeding overflow to Pond B-2. The Waste Water Treatment Plant (WWTP), also referred to as the Sewage Treatment Plant, has bypass capabilities to Ponds B-1 and B-2 in the event of an upset condition or emergency. During normal operations, the B-1 bypass conveys surface-water runoff by an underground pipeline from the bypass to Pond B-4 and subsequently to Pond B-5. During major precipitation events, storm water may be diverted prior to the B-1 bypass at the Central Avenue splitter box. These high flows are diverted directly to Pond B-5.

The WWTP discharges treated sanitary effluent to Pond B-3. Pond B-3 is impounded during evening hours and is released to Pond B-4 during daylight hours on a daily basis. Pond B-4 is a controlled flow-through pond, and all flow is conveyed to Pond B-5. Pond B-5 is the terminal pond of the B series on South Walnut Creek. In the past, water was discharged from Pond B-5 offsite. As part of current operations, water quality analysis and sampling is conducted on Pond B-5 prior to transfer to Pond A-4, for final discharge offsite. The volumetric capacity of Pond B-1 is 0.50 million gallons; Pond B-2, 1.50 million gallons; Pond B-3, 0.57 million gallons; Pond B-4, 0.18 million gallons; and Pond B-5, 24.19 million gallons.

Woman Creek

Woman Creek flows south of the main plant facility. The drainage associated with Woman Creek includes an area from the Boulder Diversion Canal to Indiana Street, encompassing approximately 1,400 acres (Figure 3.3-1). The length of Woman Creek from the RFP West Gate to Indiana Street is approximately 22,000 feet. The three sources of flow to Woman Creek are precipitation and surface runoff, seepage

from Antelope Springs and lesser seeps, and conveyance flows as a result of water rights agreements. These flows are from Kinear Ditch, Smart Ditch #1, and/or Smart Ditch #2 into Woman Creek. The Woman Creek stream flows through Pond C-1 and is then diverted around Pond C-2 by way of the Woman Creek Bypass Canal. Woman Creek flows are either diverted into the Mower Diversion Ditch or proceed in Woman Creek to Indiana Street and offsite.

Surface-water runoff from the southern portion of RFP is collected by the South Interceptor Ditch and conveyed to Pond C-2. The drainage area associated with the South Interceptor Ditch and Pond C-2 is approximately 193 acres. The South Interceptor Ditch is approximately 7,700 feet in length. Water is impounded in Pond C-2 and held for quality analysis. Upon completion of analysis, water is discharged by pipeline to the Broomfield Diversion Ditch. In the past, water was discharged to Woman Creek and entered Standley Lake. The volumetric capacity of Pond C-1 is 1.70 million gallons. The capacity of Pond C-2 is 22.60 million gallons.

MONITORING PROGRAMS

Detention Ponds Monitoring

Before discharge from Ponds A-4 and C-2, samples are taken and split for analysis among CDH, EG&G Rocky Flats, and independent EPA-registered laboratories. Discharges are monitored for parameters listed in Appendix B in compliance with NPDES permit limitations. In addition, water quality is tested before release to ensure that the water meets CWQCC standards (listed in Appendix B) for Segment 4 of Big Dry Creek. Water is released with concurrence from CDH. Carbon adsorption and filtration facilities are available for additional treatment if required. Treatment capacity at Ponds A-4 and C-2 are 1,400 gallons per minute (gpm) and 750 gpm, respectively.

Samples of all discharges from Ponds A-4 and C-2 are collected by daily composites for weekly analysis of plutonium, uranium, and americium. Tritium, pH, nitrate (as nitrogen), and nonvolatile suspended solids are analyzed daily. Chromium samples are analyzed monthly; Whole Effluent Toxicity (WET) samples are

analyzed quarterly. Monthly chromium and quarterly WET samples also are collected on Pond B-5 transfers. Discharges from Pond C-2 and flow from Walnut Creek near its intersection with Indiana Street are sampled in a similar manner. Daily samples from Pond C-2 and Walnut Creek are analyzed for tritium. Daily samples are composited weekly for plutonium, uranium, and americium analyses.

Discharges from Pond A-4, which include transfers from Pond B-5, enter Walnut Creek and are diverted around Great Western Reservoir through the Broomfield Diversion Ditch. Discharges from Pond C-2 are pumped through an 8,000-foot pipeline into the Broomfield Diversion Ditch, which eventually discharges into the South Platte River. Monthly flow and discharges for 1992 at Ponds A-4, B-5, C-2, and C-1, and for Walnut Creek at Indiana, are provided in Table 3.3-1.

Sitewide Monitoring

In addition to monitoring discharges from detention ponds, RFP conducts sitewide surface-water sampling programs to evaluate potential contaminant releases and to characterize baseline water quality. These programs assess trends and changing conditions in surface-water quality, detect extreme values or excursions beyond a limit, assess the relationship between water quality and flow, identify new contaminant sources and releases, and address surface-water sediment interactions.

Routine sitewide monitoring was initiated in early 1989 to provide surface-water quality and flow information for seeps and drainages in the main facilities area and buffer zone that may be affected by plant operations. The focus of this sampling program was to measure potential contaminants to surface water from suspected source areas such as designated CERCLA OUs. Results for 1989 were reported in the document titled *1989 Surface-Water and Sediment Geochemical Characterization Report* (EG91a). Results for 1990 were reported in the document titled *1990 Surface-Water and Sediment Geochemical Characterization Report* (EG92a).

Table 3.3-1
Monthly Flow and Discharges for 1992 (gallons)

Month	Walnut Creek at Indiana	Pond A-4	Pond B-5	Pond C-2	Pond C-1
January	8,133,000	1,084,000	No Discharge	No Discharge	7,331,000
February	4,337,000	5,310,000	No Discharge	No Discharge	5,758,000
March	77,774,000[a]	44,310,000	No Discharge	8,480,000	15,827,000
April	20,722,000	17,487,000	No Discharge	7,598,000	12,908,000
May	11,225,000	11,800,000	No Discharge	No Discharge	3,551,000
June	6,419,000	5,148,000	No Discharge	No Discharge	1,849,000
July	16,711,000	16,276,000	No Discharge	No Discharge	49,000[b]
August	862,000	No Discharge	No Discharge	No Discharge	1,215,000
September	25,514,000	27,828,000	No Discharge	No Discharge	Low Flow[c]
October	7,766,000	8,908,000	No Discharge	No Discharge	1,597,000
November	No Flow	No Discharge	No Discharge	No Discharge	3,332,000
December	22,539,000	24,116,000	No Discharge	No Discharge	5,686,000
Total	202,002,000	162,267,000	No Discharge	16,078,000	59,103,000

a. RFP was closed because of extreme blizzard conditions on March 9, 1992; no flow data is available for this date.
b. Total volume is an estimate; flow was too low to quantify for the majority of the month.
c. Flow was observed, but flow measurement equipment could not accurately quantify volume.

The sitewide monitoring program includes surface-water sampling at 30 locations and quarterly sediment sampling at approximately 20 locations plantwide. The sitewide program was modified in 1992 to accommodate data collection for RIs and additional characterization needs. This modification involved a large reduction in the number of monitoring locations and sampling frequency. The remaining sitewide stations are sampled in support of the Background Geochemical Characterization Program, which establishes baseline water quality data for waters unaffected by plant operations. These data serve as a comparison to samples from affected areas of RFP to judge the potential impact of contamination from plant activities. Results are reported in the *Background Geochemical Characterization Report for 1989* (EG90d).

The sitewide program has now provided data for 4 years of monitoring. EG&G Rocky Flats is confident these data are of adequate quality and quantity to meet DOE Order 5400.1 characterization requirements.

Additional sitewide characterization will be accomplished through storm-event monitoring at a network of approximately 13 stream gages located plantwide. Stream gages are equipped with continuously recording

stream flow monitors and automatic samplers that are programmed to sample storm-event flows. Since the potential for contaminant transport is greatest during storm events, storm-event monitoring will provide better information for characterization of contaminant fate and transport than does the current sitewide program. The DOE, RFO is entering into a new IAG with the United States Geological Survey (USGS), which will begin operation and maintenance of the gaging station network in 1993.

MONITORING RESULTS

Nonradiological Monitoring

The release of pollutants into United States waters is controlled by the NPDES permit program, which requires routine monitoring of point source discharges and reporting of results. An updated renewal application has been submitted for the RFP NPDES permit, which expired in 1989 and was extended administratively until renewed. In addition, the NPDES permit terms were modified by the NPDES FFCA that was signed by the DOE and EPA in 1991. That FFCA established an additional monitoring point at the WWTP, and added certain monitoring requirements. No Notices of Violation (NOVs) were received by RFP in 1992 for violation of NPDES standards.

Annual average concentrations of chemical and biological constituents measured in surface-water effluent samples as part of the NPDES FFCA are provided in Table 3.3-2. Concentrations are indicative of the overall quality of effluent discharges. Certain discharges must meet NPDES permit monitoring and compliance limitations described in Appendix B.

Radiological Monitoring

Concentrations of plutonium, uranium, americium, and tritium in water samples from the outfalls of Ponds A-4, C-1, C-2, and from Walnut Creek at Indiana Street are presented in Tables 3.3-3 and 3.3-4. Mean plutonium, uranium, americium, and tritium concentrations at all sample locations were less than 0.24 percent of applicable DCGs (Appendix B).

Table 3.3-2

Chemical and Biological Constituents in Surface-Water Effluents at NPDES Permit Discharge Locations 1992 [a, b]

Parameters	Number of Analyses	C minimum[c]	C maximum[c]	C mean[c, d]
Discharge 001 (Pond B-3)				
Nitrate as N, mg/l	106	0.28	13.7	3.36
Total Residual Chlorine, mg/l	366	0	1.9	0.03
Discharge 002 (Pond A-3)				
pH, standard units	55	7.16	8.48	N/A
Nitrate as N, mg/l	56	0	3.8	1.7
Discharge 003 (Reverse Osmosis Pilot Plant)	During 1992 there were no discharges.			
Discharge 004 (Reverse Osmosis Plant)	During 1992 there were no discharges.			
Discharge 005 (Pond A-4)				
Total Chromium, µg/l	10	<2.4	<7	<6.2
Discharge 006 (Pond B-5)	During 1992 there were no discharges.			
Discharge 007 (Pond C-2)				
Total Chromium, µg/l	2	<7	<7	<7
Discharge 995 (Wastewater Treatment Plant)				
pH, standard units	366	4.11	7.88	N/A
Total Suspended Solids, mg/l	151	0	18	5.7
Oil and Grease, mg/l	0	0	0	0
Total Phosphorus, mg/l	149	<0.01	6.1	0.23
Total Chromium, µg/l	51	<2.4	11.9	5.5
Fecal Coliform, #/100ml	146	<1	36	1.4
Carbonaceous Biochemical Oxygen Demand, mg/l	146	0.1	15	2

a. NPDES permit limitations are presented in Appendix B.

b. Average annual concentration reported for each parameter is an estimate of central tendency (mean value) for all samples collected during the year. This provides an estimate of average effluent water quality for the entire year. The maximum values listed are the highest values observed and represent the worst-case scenario for the entire year. The NPDES permit limits are specified as "Monthly Average" and "Weekly Average" and are measures of central tendency for the shorter time periods as required by the permit. The "Daily Maximum" is the largest value measured during the month. EPA has established limits for these required reporting intervals.

c. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean measured concentration.

d. For Fecal Coliform, #/100 ml geometric mean used.

Table 3.3-3

Plutonium, Uranium, and Americium Concentrations in Surface-Water Effluents

Location	Number of Analyses	C minimum[a, b, c]	C maximum[a, b]	C mean[a, c]	Percent of DCG (C mean)
Plutonium-239, -240 Concentration (x 10^{-9} µCi/ml)[d]					
Pond A-4	16	-0.011 ± 0.006	0.011 ± 0.007	0.001 ± 0.001	0.00
Pond C-1	46	-0.015 ± 0.005	0.088 ± 0.023	0.010 ± 0.005	0.03
Pond C-2	2	0.010 ± 0.004	0.032 ± 0.006	0.025 ± 0.004	0.08
Walnut Creek at Indiana Street	21	-0.013 ± 0.008	0.078 ± 0.014	0.004 ± 0.001	0.01
Uranium-233, -234 Concentration (x 10^{-9} µCi/ml)[e]					
Pond A-4	18	0.36 ± 0.06	1.54 ± 0.21	0.79 ± 0.03	0.16
Pond C-1	49	0.11 ± 0.06	1.35 ± 0.16	0.72 ± 0.08	0.14
Pond C-2	3	0.79 ± 0.11	0.98 ± 0.14	0.88 ± 0.07	0.18
Walnut Creek at Indiana Street	21	0.23 ± 0.07	1.44 ± 0.16	0.83 ± 0.03	0.17
Uranium-238 Concentration (x 10^{-9} µCi/ml)[e]					
Pond A-4	18	0.25 ± 0.05	1.29 ± 0.14	0.83 ± 0.03	0.14
Pond C-1	49	0.11 ± 0.06	1.06 ± 0.15	0.53 ± 0.06	0.09
Pond C-2	3	1.39 ± 0.17	1.52 ± 0.15	1.43 ± 0.10	0.24
Walnut Creek at Indiana Street	21	0.11 ± 0.05	1.46 ± 0.12	0.79 ± 0.03	0.13
Americium Concentration (x 10^{-9} µCi/ml)[f]					
Pond A-4	18	-0.020 ± 0.005	0.012 ± 0.003	0.001 ± 0.001	0.00
Pond C-1	47	-0.017 ± 0.007	0.020 ± 0.011	0.001 ± 0.002	0.01
Pond C-2	2	0.002 ± 0.002	0.003 ± 0.002	0.003 ± 0.002	0.01
Walnut Creek at Indiana Street	21	-0.015 ± 0.006	0.032 ± 0.006	0.005 ± 0.001	0.02

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration. For Pond C-1, C mean refers to calculated mean concentration. Because of intermittent flow meter operations at Pond C-1 during 1992, a volume weighted average was not possible to calculate. For Ponds A-4, C-2, and flow at Walnut Creek at Indiana Street, C mean refers to volume weighted averages.

b. Calculated as 1.96 standard deviations of the individual measurement.

c. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).

d. Radiochemically determined as plutonium-239 and -240. The DOE Derived Concentration Guide (DCG) for plutonium in water available to members of the public is 30 x 10^{-9} µCi/ml (Appendix B).

e. Radiochemically determined as uranium-233, -234, and -238. The DOE DCG for uranium-233, -234 in water available to members of the public is 500 x 10^{-9} µCi/ml. The DCG for uranium-238 in water is 600 x 10^{-9} µCi/ml (Appendix B).

f. Radiochemically determined as americium-241. The standard calculated DCG for americium in water available to members of the public is 30 x 10^{-9} µCi/ml (Appendix B).

Table 3.3-4

Tritium Concentrations in Surface-Water Effluents

Location	Number of Analyses	C minimum[a, b]	C maximum[a, b]	C mean[a, c]	Percent of DCG (C mean)
		Tritium Concentration (x 10^{-9} µCi/ml)[d]			
Pond A-4	100	-330 ± 91	762 ± 101	59 ± 11	0.00
Pond C-1	43	-193 ± 98	390 ± 231	46 ± 39	0.02
Pond C-2	13	-187 ± 85	101 ± 86	-19 ± 25	0.00
Walnut Creek at Indiana Street	120	-661 ± 154	383 ± 92	5 ± 11	0.00

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration. For Pond C-1, C mean refers to calculated mean concentration. Due to intermittent flow meter operations at Pond C-1 during 1992, a volume weighted average was not possible to calculate. For Ponds A-4, C-2, and flow at Walnut Creek at Indiana Street, C mean refers to volume weighted averages.

b. Calculated as 1.96 standard deviations of the individual measurement.

c. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).

d. The DOE DCG for tritium in water available to the members of the public is 2,000,000 x 10^{-9} µCi/ml (Appendix B).

The annual cumulative total amount of plutonium, uranium, and americium discharged to offsite waters during the year was calculated using each individual discharge concentration and flow measurement. Following are the cumulative discharge amounts for 1992.

	Pond A-4	Pond C-2
Pu - Ci (Bq)	5.28×10^{-7} (1.95×10^{4})	1.12×10^{-6} (4.26×10^{4})
U-234 - Ci (Bq)	5.03×10^{-4} (1.86×10^{8})	5.34×10^{-5} (1.98×10^{6})
U-238 - Ci (Bq)	5.30×10^{-4} (1.96×10^{7})	8.68×10^{-5} (3.21×10^{6})
Am - Ci (Bq)	7.44×10^{-7} (2.75×10^{4})	1.24×10^{-7} (4.60×10^{3})

Tritium concentrations in water discharged from these ponds were within the range of background concentrations; therefore, cumulative discharge amounts were not calculated. Average annual concentrations of plutonium, uranium, and americium from Ponds A-4 and C-2 for 1988 through 1992 are given in Figures 3.3-2, 3.3-3, and 3.3-4.

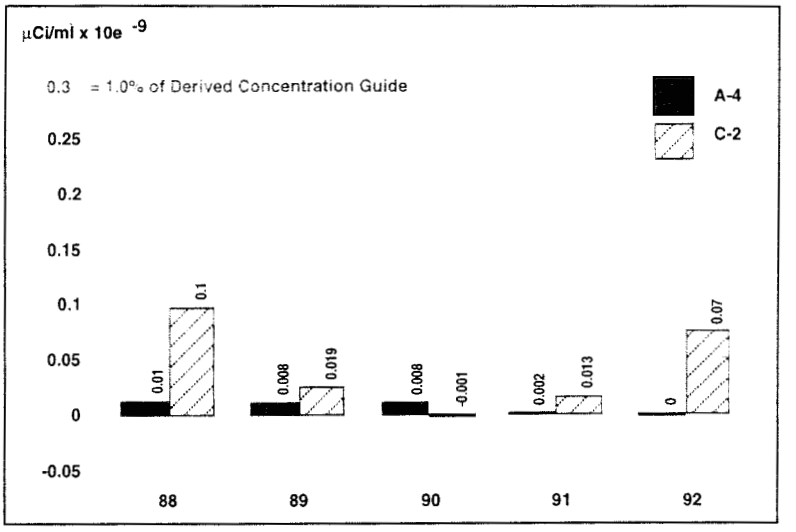


Figure 3.3-2. Plutonium-239, -240

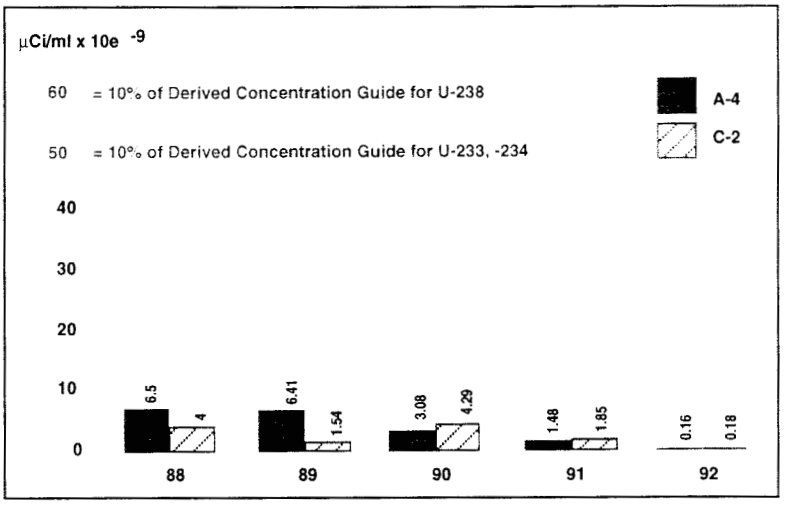


Figure 3.3-3. Uranium-233, -234, -238 Composited

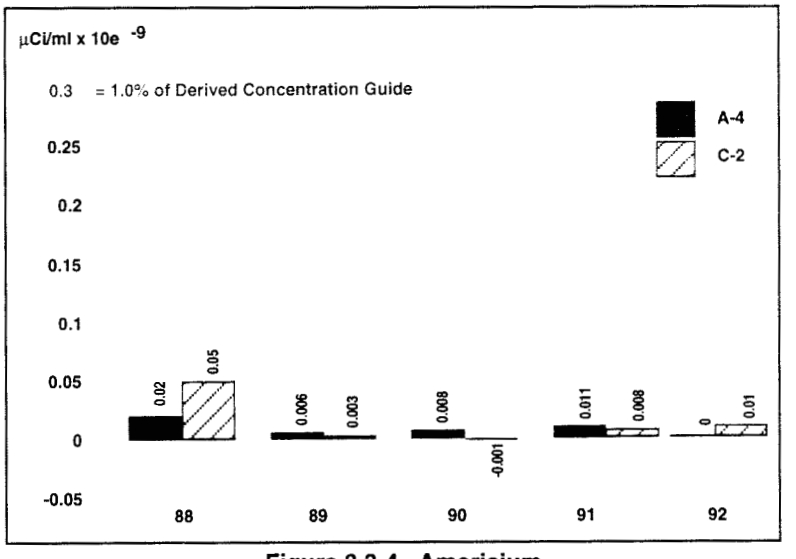


Figure 3.3-4. Americium

During 1992, RFP's raw water supply was obtained from Ralston Reservoir and from the South Boulder Diversion Canal. Ralston Reservoir water usually contains more natural uranium radioactivity than the water flowing from the South Boulder Diversion Canal. During the year, uranium, plutonium, americium, and tritium analyses were performed monthly on samples of RFP raw water. Concentrations are presented in Table 3.3-5. These values can be used for comparison with the values measured in the RFP downstream discharge locations (Tables 3.3-3 and 3.3-4).

Table 3.3-5

Plutonium, Uranium, Americium, and Tritium Concentrations in the Raw Water Supply

Analyte	Number of Analyses	C minimum[a, b]	C maximum[a, b]	C mean[a, c]	Percent of DCG (C mean)
Plutonium Concentration ($\times 10^{-9}$ µCi/ml)[d]	11	-0.012 ± 0.004	0.006 ± 0.004	-0.002 ± 0.003	-0.01
Uranium-233, -234 Concentration ($\times 10^{-9}$ µCi/ml)[e]	11	0.06 ± 0.07	0.96 ± 0.12	0.36 ± 0.20	0.07
Uranium-238 Concentration ($\times 10^{-9}$ µCi/ml)[e]	11	0.03 ± 0.06	0.75 ± 0.10	0.31 ± 0.16	0.05
Americium Concentration ($\times 10^{-9}$ µCi/ml)[f]	11	-0.004 ± 0.004	0.026 ± 0.013	0.003 ± 0.005	0.01
Tritium Concentration ($\times 10^{-9}$ µCi/ml)[g]	7	-133 ± 90	427 ± 94	55 ± 138	0.00

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean calculated concentration.
b. Calculated as 1.96 standard deviations of the individual measurement.
c. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).
d. Radiochemically determined as plutonium-239 and -240. The DOE Derived Concentration Guide (DCG) for plutonium in water available to members of the public is 30 x 10^{-9} µCi/ml (Appendix B).
e. Radiochemically determined as uranium-233, -234 and -238. The DOE DCG for uranium-233, -234 in water available to members of the public is 500 x 10^{-9} µCi/ml. The DCG for uranium-238 in water is 600 x 10^{-9} µCi/ml (Appendix B).
f. Radiochemically determined as americium-241. The standard calculated DCG for americium in water available to members of the public is 30 x 10^{-9} µCi/ml (Appendix B).
g. The DOE DCG for tritium in water available to members of the public is 2,000,000 x 10^{-9} µCi/ml (Appendix B).

COMMUNITY WATER MONITORING

Sampling and analysis of public water supplies and tap water from several surrounding communities are the focus of RFP's community water monitoring program. Only two reservoirs, Great Western Reservoir, serving the city of Broomfield, and Standley Lake Reservoir, a water supply for the cities of Westminster, Thornton, and Northglenn, have the potential to receive runoff from RFP drainage systems. The city of Federal Heights also purchases a portion of its water supply from the city of Westminster. All discharges from RFP detention ponds in 1992 were diverted to the Broomfield Diversion Ditch and did not enter either Great Western or Standley Lake Reservoir. During most of 1992, weekly samples were collected and composited into a monthly sample, and analyses were performed for plutonium, uranium, and americium concentrations. Tritium and nitrate (as N) analyses were conducted on weekly grab samples.

Beginning in FY93 (October 1, 1992), sampling at all offsite locations, including all monthly and quarterly community and annual remote sites, was deleted from the routine program in an effort to better utilize available funding. As demonstrated by historic data, discharges from RFP do not impact drinking water supplies and continued routine sampling was not warranted.

During 1992, annual background samples were collected from Ralston, Dillon, and Boulder reservoirs, at distances ranging from 1 to 60 miles from RFP. Samples were collected to determine background levels for plutonium, uranium, americium, and tritium in water.

Drinking water from Boulder, Broomfield, and Westminster was collected weekly, composited monthly, and analyzed for plutonium, uranium, and americium. (The sampling frequency of drinking water in Boulder was changed from monthly to quarterly in June 1992 because of limited resources and because of the absence of any identified RFP impacts on Boulder drinking water.) Analyses for tritium were performed weekly. Tap water samples were collected quarterly from the communities of Arvada, Denver, Golden, Lafayette, Louisville, and Thornton. These samples were analyzed for plutonium, uranium, americium, and tritium.

Table 3.3-6
Plutonium and Uranium Concentrations in Public Water Supplies

Location	Number of Analyses	C minimum[a, b]	C maximum[a, b]	C mean[a, c]	Percent of DCG (C mean)
Reservoir		**Plutonium-239, -240 Concentration (x 10^{-9} µCi/ml)[d]**			
Boulder	1	-0.013 ± 0.006	-0.013 ± 0.006	-0.013 ± 0.006	-0.04
Dillon	1	0.028 ± 0.005	0.028 ± 0.005	0.028 ± 0.005	0.09
Great Western	10	-0.032 ± 0.015	0.008 ± 0.003	-0.003 ± 0.007	-0.01
Ralston	1	-0.021 ± 0.004	-0.021 ± 0.004	-0.021 ± 0.004	-0.07
South Boulder Diversion Canal[e]					
Standley	10	-0.014 ± 0.005	0.001 ± 0.004	-0.005 ± 0.004	-0.02
Drinking Water					
Arvada	3	-0.010 ± 0.006	0.004 ± 0.002	-0.002 ± 0.008	-0.01
Boulder	6	-0.016 ± 0.006	0.007 ± 0.006	-0.003 ± 0.007	-0.01
Broomfield	9	-0.014 ± 0.004	0.055 ± 0.008	0.003 ± 0.013	0.01
Denver	3	-0.016 ± 0.004	0.001 ± 0.002	-0.006 ± 0.010	-0.02
Golden	3	-0.034 ± 0.009	0.004 ± 0.003	-0.011 ± 0.023	-0.04
Lafayette	3	-0.012 ± 0.006	0.002 ± 0.002	-0.005 ± 0.008	-0.02
Louisville	3	-0.010 ± 0.006	0.002 ± 0.002	-0.003 ± 0.007	-0.01
Thornton	3	-0.016 ± 0.005	0.001 ± 0.003	-0.006 ± 0.010	-0.02
Westminster	10	-0.022 ± 0.006	0.016 ± 0.009	0.001 ± 0.007	0.00
Reservoir		**Uranium-233, -234 Concentration (x 10^{-9} µCi/ml)[f]**			
Boulder	1	0.32 ± 0.05	0.32 ± 0.05	0.32 ± 0.05	0.06
Dillon	1	0.28 ± 0.07	0.28 ± 0.07	0.28 ± 0.07	0.06
Great Western	9	0.14 ± 0.06	0.60 ± 0.06	0.35 ± 0.09	0.07
Ralston	1	0.80 ± 0.09	0.80 ± 0.09	0.80 ± 0.09	0.16
South Boulder Diversion Canal[e]					
Standley	10	0.00 ± 0.00	0.80 ± 0.08	0.50 ± 0.13	0.10
Drinking Water					
Arvada	3	0.00 ± 0.07	0.21 ± 0.07	0.10 ± 0.12	0.02
Boulder	6	-0.22 ± 0.04	-0.02 ± 0.01	-0.16 ± 0.06	-0.03
Broomfield	9	-0.09 ± 0.05	0.18 ± 0.03	0.08 ± 0.05	0.02
Denver	3	-0.06 ± 0.06	0.89 ± 0.09	0.44 ± 0.54	0.09
Golden	3	0.10 ± 0.07	0.49 ± 0.06	0.27 ± 0.23	0.05
Lafayette	3	-0.12 ± 0.08	0.01 ± 0.02	-0.07 ± 0.08	-0.01
Louisville	3	-0.20 ± 0.06	-0.02 ± 0.02	-0.13 ± 0.11	-0.03
Thornton	3	0.35 ± 0.08	0.36 ± 0.08	0.36 ± 0.01	0.07
Westminster	10	-0.02 ± 0.07	0.27 ± 0.08	0.07 ± 0.06	0.01

Table 3.3-6 (continued)
Plutonium and Uranium Concentrations in Public Water Supplies

Location	Number of Analyses	C minimum[a, b]	C maximum[a, b]	C mean[a, c]	Percent of DCG (C mean)
Reservoir		**Uranium-238 Concentration (x 10^{-9} µCi/ml)[g]**			
Boulder	1	0.18 ± 0.03	0.18 ± 0.03	0.18 ± 0.03	0.03
Dillon	1	0.35 ± 0.07	0.35 ± 0.07	0.35 ± 0.07	0.06
Great Western	8	0.18 ± 0.06	0.61 ± 0.06	0.35 ± 0.07	0.06
Ralston	1	0.93 ± 0.10	0.93 ± 0.10	0.93 ± 0.10	0.16
South Boulder Diversion Canal[e]					
Standley	10	0.20 ± 0.03	0.67 ± 0.07	0.45 ± 0.08	0.07
Drinking Water					
Arvada	3	0.00 ± 0.06	0.20 ± 0.06	0.08 ± 0.12	0.01
Boulder	6	-0.18 ± 0.04	-0.03 ± 0.01	-0.14 ± 0.05	-0.02
Broomfield	9	-0.07 ± 0.05	0.19 ± 0.03	0.09 ± 0.05	0.02
Denver	3	-0.09 ± 0.05	0.42 ± 0.06	0.19 ± 0.29	0.03
Golden	3	0.10 ± 0.06	0.47 ± 0.06	0.26 ± 0.22	0.04
Lafayette	3	-0.10 ± 0.05	0.00 ± 0.02	-0.06 ± 0.06	-0.01
Louisville	3	-0.16 ± 0.05	0.00 ± 0.01	-0.10 ± 0.10	-0.02
Thornton	3	0.28 ± 0.07	0.36 ± 0.05	0.31 ± 0.05	0.05
Westminster	10	-0.04 ± 0.04	0.18 ± 0.06	0.06 ± 0.04	0.01

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean calculated concentration.
b. Calculated as 1.96 standard deviations of the individual measurements.
c. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).
d. Radiochemically determined as plutonium-239 and -240. The DOE DCG for plutonium in water available to members of the public is 30 x 10^{-9} µCi/ml (Appendix B).
e. Location was not sampled in 1992.
f. Radiochemically determined as uranium-233 and -234. The DOE DCG for uranium in water available to members of the public is 500 x 10^{-9} µCi/ml (Appendix B).
g. Radiochemically determined as uranium-238. The DOE DCG for uranium in water available to members of the public is 600 x 10^{-9} µCi/ml (Appendix B).

Table 3.3-7
Americium and Tritium Concentrations in Public Water Supplies

Location	Number of Analyses	C minimum[a, b]	C maximum[a, b]	C mean[a,c]	Percent of DCG (C mean)
Reservoir		**Americium Concentration (x 10^{-9} µCi/ml)[d]**			
Boulder	1	0.000 ± 0.013	0.000 ± 0.013	0.000 ± 0.013	0.00
Dillon	1	0.012 ± 0.006	0.012 ± 0.006	0.012 ± 0.006	0.04
Great Western	10	-0.005 ± 0.009	0.011 ± 0.005	0.002 ± 0.003	0.01
Ralston	1	0.003 ± 0.014	0.003 ± 0.014	0.003 ± 0.014	0.01
South Boulder Diversion Canal[e] Standley	10	-0.007 ± 0.001	0.002 ± 0.002	-0.001 ± 0.002	0.00
Drinking Water					
Arvada	3	-0.019 ± 0.013	0.003 ± 0.009	-0.006 ± 0.013	-0.02
Boulder	6	-0.014 ± 0.006	0.001 ± 0.004	-0.004 ± 0.004	-0.01
Broomfield	9	-0.007 ± 0.008	0.016 ± 0.006	-0.001 ± 0.004	0.00
Denver	3	-0.008 ± 0.006	-0.004 ± 0.015	-0.005 ± 0.003	-0.02
Golden	3	-0.010 ± 0.008	0.058 ± 0.018	0.016 ± 0.042	0.05
Lafayette	3	-0.003 ± 0.008	0.004 ± 0.012	0.000 ± 0.004	0.00
Louisville	3	-0.004 ± 0.002	0.004 ± 0.010	-0.001 ± 0.005	0.00
Thornton	3	-0.019 ± 0.013	0.007 ± 0.014	-0.006 ± 0.015	-0.02
Westminster	10	-0.012 ± 0.008	0.014 ± 0.004	-0.009 ± 0.004	0.00
Reservoir		**Tritium Concentration (x 10^{-9} µCi/ml)[f]**			
Boulder	1	61 ± 90	61 ± 90	61 ± 90	0.00
Dillon	1	78 ± 87	78 ± 87	78 ± 87	0.00
Great Western	38	-240 ± 183	252 ± 239	-4 ± 38	0.00
Ralston	1	-18 ± 93	-18 ± 93	-18 ± 93	0.00
South Boulder Diversion Canal[e] Standley	39	-228 ± 96	430 ± 100	8 ± 34	0.00
Drinking Water					
Arvada	3	-25 ± 97	80 ± 80	13 ± 66	0.00
Boulder	20	-220 ± 183	193 ± 183	-2 ± 48	0.00
Broomfield	37	-315 ± 89	162 ± 97	-9 ± 34	0.00
Denver	3	-111 ± 83	94 ± 94	-14 ± 116	0.00
Golden	3	-148 ± 88	69 ± 93	-17 ± 130	0.00
Lafayette	3	-165 ± 96	24 ± 92	-62 ± 108	0.00
Louisville	3	28 ± 87	69 ± 88	46 ± 24	0.00
Thornton	3	-144 ± 89	11 ± 84	-49 ± 94	0.00
Westminster	37	-233 ± 86	391 ± 96	1 ± 42	0.00

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean calculated concentration.
b. Calculated as 1.96 standard deviations of the individual measurements.
c. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).
d. Radiochemically determined as americium-241. The DOE DCG for americium in water available to members of the public is 30 x 10^{-9} µCi/ml (Appendix B).
e. Location was not sampled in 1992.
f. The DOE DCG for tritium in water available to members of the public is 2,000,000 x 10^{-9} µCi/ml (Appendix B).

Sampling for 1992 was performed from January through October and is presented in Tables 3.3-6 and 3.3-7. The CDH has scheduled inclusion of all community sites deleted by RFP into its routine program. Collection frequency will be quarterly grab samples for annual composites. Locations include Arvada, Boulder, Denver, Golden, Lafayette, Louisville, Thornton, Boulder Reservoir, and Dillon Reservoir. The CDH water sampling program currently includes Great Western Reservoir, Broomfield, Standley Lake, and Westminster. The sampling frequency for these locations is weekly composites of daily grab samples for quarterly analysis.

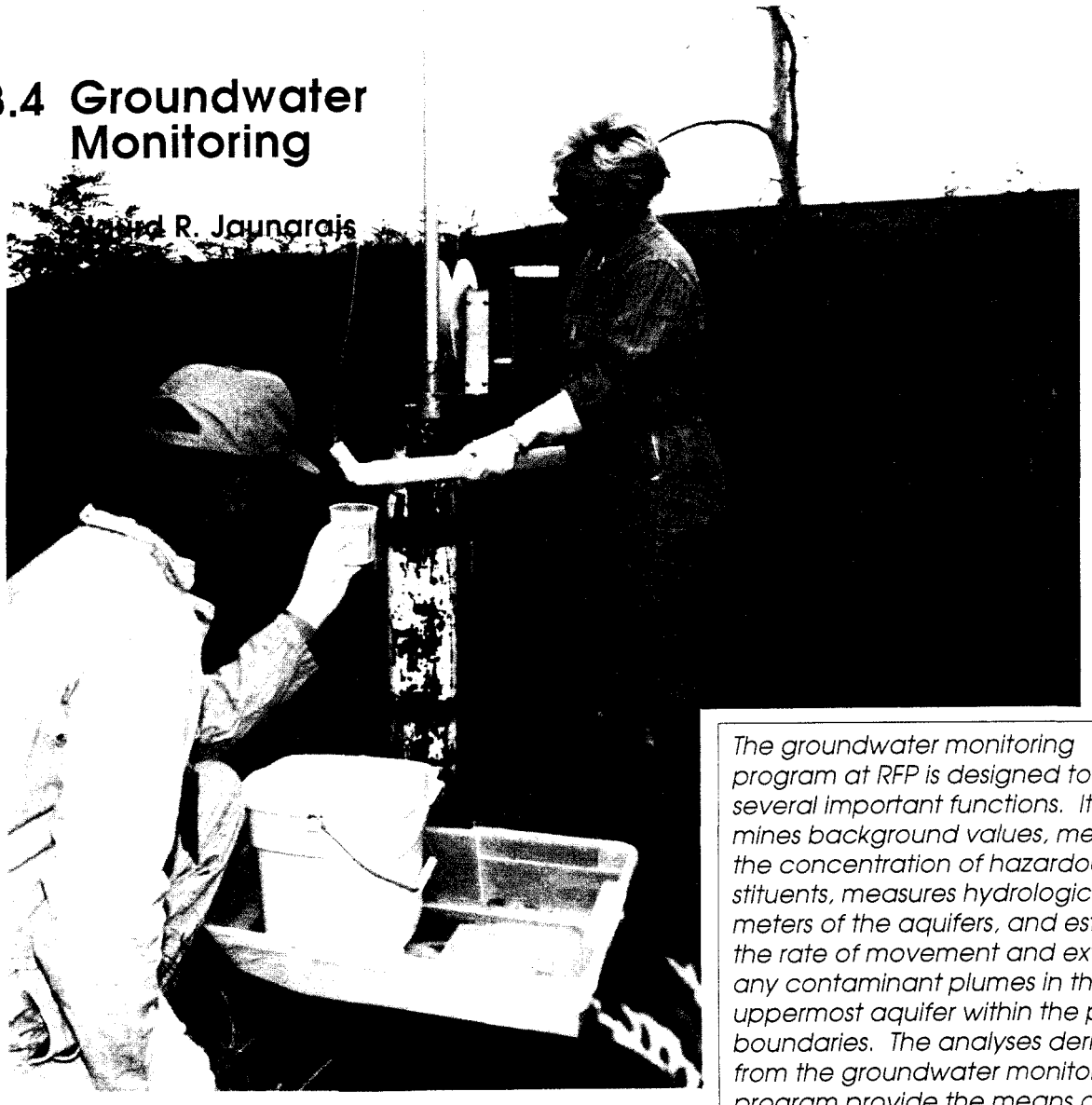
RESULTS

Analyses of regional reservoir and drinking water samples are presented in Tables 3.3-6 and 3.3-7. Plutonium, uranium, americium, and tritium concentrations for regional reservoirs represented 0.16 percent or less of the DCG. Average plutonium concentration in Great Western Reservoir was -0.003×10^{-9} µCi/ml ($.11 \times 10^{-4}$ Bq/l), which was within the range of concentrations predicted for Great Western Reservoir in the *Environmental Impact Statement, Rocky Flats Plant Site* (DOE80) based on known low-level plutonium concentrations in reservoir sediments.

Results of plutonium, uranium, americium, and tritium analyses for drinking water in nine communities were 0.09 percent or less of the applicable DCG. Drinking water standards have been adopted by the State of Colorado (CDH77, CDH81) and EPA (EPA76a) for alpha-emitting radionuclides (15×10^{-9} µCi/ml [5.55×10^{-1} Bq/l]) and for tritium ($20{,}000 \times 10^{-9}$ µCi/ml [7.4×10^{2} Bq/l]). These standards exclude uranium and radon. During 1992, the largest mean concentration of alpha-emitting radionuclides for community tap water was 0.016×10^{-9} µCi/ml (5.92×10^{-4} Bq/l) for americium. This value was 0.11 percent of the State of Colorado and EPA drinking water standards for alpha activity. Average tritium concentration in Great Western Reservoir, Standley Lake, and in all community tap water samples was less than 46×10^{-9} µCi/ml (1.702 Bq/l) or less. That value is typical of background tritium concentrations in Colorado and is less than 0.23 percent of the State of Colorado and EPA drinking water standards for tritium (CDH81, EPA76a).

3.4 Groundwater Monitoring

Edward R. Jaunarajs



The groundwater monitoring program at RFP is designed to serve several important functions. It determines background values, measures the concentration of hazardous constituents, measures hydrologic parameters of the aquifers, and estimates the rate of movement and extent of any contaminant plumes in the uppermost aquifer within the plant boundaries. The analyses derived from the groundwater monitoring program provide the means of evaluating the impacts of plant operations on groundwater and limiting activities that may adversely affect the quality of groundwater in the area.

OVERVIEW

The current RFP Groundwater Monitoring Program includes a network of wells and piezometers installed to characterize groundwater and hydrogeology. The monitoring program has been designed and implemented to satisfy dual objectives related to both monitoring and site characterization. Monitoring objectives include providing information on the presence, nature, areal extent, fate, and transport of contaminated groundwater; providing data for trend evaluation, site characterization, and treatability studies; providing groundwater data to government agencies and surrounding communities; and maintaining a database of analytical results.

Characterization objectives include identifying hydrostratigraphic units; evaluating groundwater pathways and migration characteristics; qualifying and quantifying the interrelationships between groundwater and surface water at RFP, and the relationship among precipitation, infiltration, and groundwater recharge; and helping establish background analyte concentrations and characterizing background groundwater geochemical interactions.

This section provides information related to the RFP Groundwater Monitoring Program, including information on the geologic setting, hydrogeology, monitoring procedures, and results recorded during 1992.

Geologic Setting

Underlying RFP is a series of stratigraphic units at increasing depths from surface deposits (recent valley fill and loose rock debris) through the Rocky Flats Alluvium, Arapahoe Formation, Laramie Formation, and Fox Hills Sandstone to the Pierre Shale (Figure 3.4-1). The Rocky Flats Alluvium, colluvium, and Arapahoe Formation comprise the uppermost hydrologic unit where potential groundwater contamination might occur at RFP. A description of the geology of RFP is provided in the *Geologic Characterization of the Rocky Flats Plant* (EG91f).

The Rocky Flats Alluvium is composed of cobbles, coarse gravel, sand, and gravely clay, varying in thickness across RFP from approximately 103 feet on the west side, to less than 10 feet in the central area, and 45 feet on the east side. The Arapahoe Formation is approximately 120 feet thick in the central portion of RFP. It consists primarily of fluvial claystone overbank deposits and lesser amounts of sandstone channel deposits. The sandstones range from very fine grained to conglomerate.

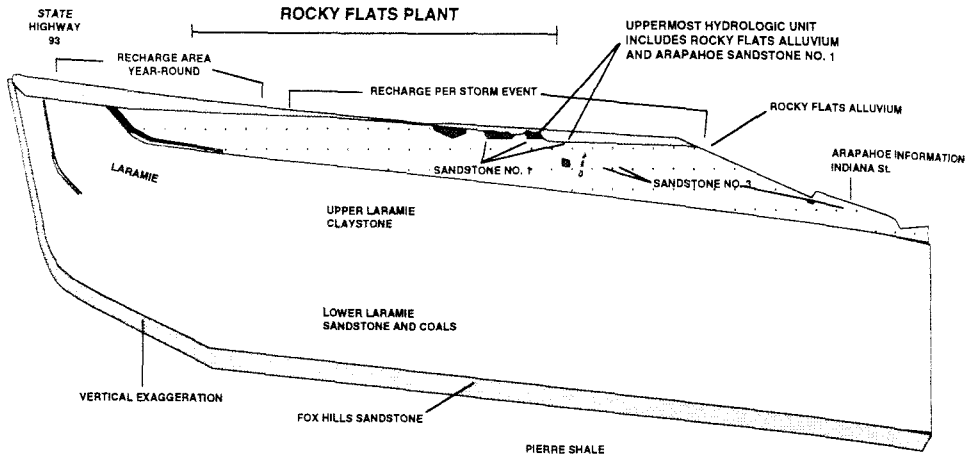


Figure 3.4-1. Generalized Cross Section of the Stratigraphy Underlying the RFP

Hydrogeology

The Rocky Flats Alluvium and the weathered subcropping Arapahoe Sandstones are in hydraulic connection and together represent the "uppermost aquifer," which is an unconfined flow system (Figure 3.4-1). The bedrock sandstones of the Laramie Formation are isolated within intervals of claystone. Groundwater contained in those bedrock sandstones is confined and represents a lower flow system. Table 3.4-1 provides the relative hydraulic conductivities associated with the lithologic units present at RFP. Hydraulic conductivity is a measure of the capacity of a porous medium to transmit water. It helps determine how fast groundwater and any accompanying contamination travel beneath the surface.

Table 3.4-1
Hydraulic Conductivities of Lithologic Units

Lithologic Unit	Hydraulic Conductivity
Rocky Flats Alluvium	1×10^{-5} cm/sec (10.4 ft/yr)
Subcropping Arapahoe sandstones	1×10^{-5} cm/sec (10.4 ft/yr)
Unweathered sandstones	1×10^{-6} cm/sec (1.04 ft/yr)
Weathered and unweathered claystone	1×10^{-7} to 10^{-8} cm/sec (0.104 to 0.0104 ft/yr)

In the spring and early summer, the Rocky Flats Alluvium and Arapahoe Formation, located in the central and eastern portion of RFP, are recharged by precipitation and groundwater lateral flow. In the late summer and early fall these formations are recharged primarily by groundwater lateral flow. In the stream drainages, groundwater discharges at seeps common at the base of the Rocky Flats Alluvium and where individual sandstones become exposed to the surface.

The present understanding of the hydrogeologic relationships indicates that there are no known bedrock pathways through which groundwater contamination can directly leave RFP and migrate into a confined aquifer system offsite (EG91f).

Monitoring Program and Procedures

By the end of 1992, there were approximately 500 wells in the groundwater monitoring program, 430 of which are sampled on a regular basis (Figure 3.4-2). Approximately 30 new wells were installed during 1992. These new wells support increased groundwater monitoring activities in the 881 Hillside Area (OU 1), the Woman Creek drainage (OU 5), and Walnut Creek drainage (OU 6).

Groundwater samples are collected quarterly from alluvial and bedrock wells. These samples are analyzed at several offsite laboratories for parameters shown in Table 3.4-2. These wells are spatially distributed throughout RFP to provide the necessary coverage to satisfy RCRA/CERCLA and plant protection guidelines for monitoring groundwater at hazardous waste sites. Some wells are used to help characterize hydrogeologic conditions at RFP, while others are used to monitor background groundwater quality. Wells in the RFP Groundwater Monitoring Program are subdivided into six subsets according to purpose and regulatory requirements. Each well in the network has been classified as either a background, RCRA regulatory, RCRA characterization, CERCLA, boundary, or special purpose well.

- Background wells monitor the groundwater in areas upgradient or cogradient of the RFP.
- RCRA regulatory wells characterize and/or monitor the uppermost aquifer for RCRA units.

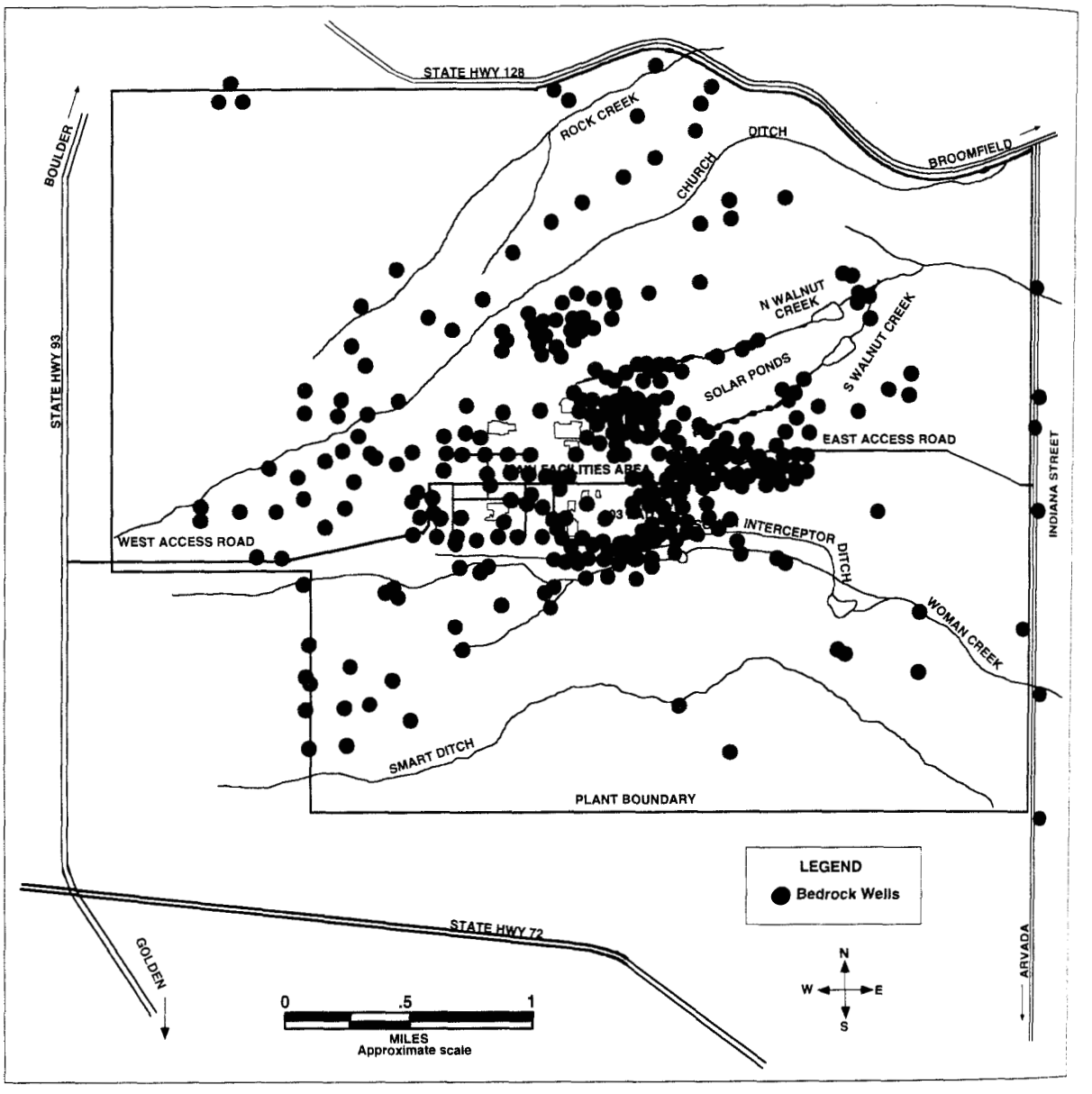


Figure 3.4-2. Location of Monitoring Wells

Table 3.4-2

Site Chemical Constituents Monitored in Groundwater

Dissolved Metals

Cesium (Cs)
Lithium (Li)[a]
Molybdenum (Mo)
Strontium (Sr)
Tin (Sn)[b]

Target Analyte List:

Aluminum (Al)
Antimony (Sb)
Arsenic (As)
Barium (Ba)
Beryllium (Be)
Cadmium (Cd)
Calcium (Ca)
Chromium (Cr)
Cobalt (Co)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Magnesium (Mg)
Manganese (Mn)
Mercury (Hg)
Nickel (Ni)
Potassium (K)
Selenium (Se)
Silver (Ag)
Sodium (Na)
Thallium (Tl)
Vanadium (V)
Zinc (Zn)

Organics [c]

Target Compound List - Volatiles:
Chloromethane (CH_3CL)
Bromomethane (CH_3Br)
Vinyl Chloride (C_2H_3CL)
Chloroethane (C_2H_5CL)
Methylene Chloride (CH_2CL_2)
Acetone
Carbon Disulfide
1,1-Dichloroethane (1,1-DCA)
1,1,-Dichloroethene (1,1-DCE)
trans-1,2-Dichloroethene
1,2-Dichloroethene (total) (total 1,2-DCE)
Chloroform ($CHCl_3$)
1,2-Dichloroethane (1,2-DCA)
2-Butanone (MEK)
1,1,1-Trichloroethane (1,1,1-TCA)
Carbon Tetrachloride (CCl_4)
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane (1,2-DCP)
trans-1,3-Dichloropropene
Trichloroethene (TCE)
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
Bromoform (CBr_4)
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene (PCE)
Toluene (C_7H_8)
Chlorobenzene (C_6H_5CL)
Ethyl Benzene
Styrene
Total Xylenes

Dissolved Radionuclides [d]

Gross Alpha
Gross Beta
Uranium-233, -234, -235, and -238 (U-233, -234, -235; and -238)
Strontium-89, -90 (Sr-89, -90)[e]
Cesium-137 (Cs-137)
Tritium (H-3)
Radium-226, -228 (Ra-226, -228)[f]

Total Radionuclides

Americium-241 (Am-241)
Plutonium-239, -240 (Pu-239, -240)

Indicators

Total Dissolved Solids (TDS)
pH[b]

Field Parameters

pH
Specific Conductance
Temperature
Dissolved Oxygen
Alkalinity

Anions

Carbonate (CO_3)
Bicarbonate (HCO_3)
Chloride (Cl)
Sulfate (SO_4)
Nitrate/Nitrite (NO_2/NO_3 as N)
Cyanide (CN)[g]
Fluoride (F)
Orthophosphates (PO_4)

a. Before 1989, lithium was only analyzed during fourth quarter 1987 and first quarter 1988.
b. Not analyzed before 1989.
c. Not analyzed in background samples in 1989.
d. Dissolved radionuclides replaces total radionuclides (except tritium) beginning with the third quarter 1987; however, total Pu and Am were collected starting in third quarter 1990.
e. Strontium-89, -90 was not analyzed during first quarter 1988.
f. Not analyzed before 1989, and only analyzed if gross alpha exceeds 5 pCi/l.
g. Cyanide was not analyzed during fourth quarter 1987.

NOTES:
- Total suspended solids and phosphate were analyzed in 1986 only; orthophosphates were analyzed in 1990 and 1991.
- Chromium (VI) was analyzed during fourth quarter 1987 only.

- RCRA characterization wells characterize and/or monitor aquifers other than the uppermost aquifer at or near RCRA units.

- CERCLA wells characterize and/or monitor the groundwater for CERCLA units.

- Boundary wells monitor the movement and quality of groundwater at the downgradient boundaries of RFP.

- Special purpose wells include other wells installed at RFP that are used to characterize groundwater and hydrogeology for a variety of purposes.

Quarterly water-level measurements are taken to adequately assess groundwater flow directions. These data are used to evaluate trends in groundwater quality and contaminant migration in the uppermost, unconfined aquifer.

During 1992, RFP performed monitoring well abandonment and replacement under the Well Abandonment and Replacement Program (WARP). WARP was developed to mitigate the potential for contaminant migration through improperly constructed or damaged wells, and to ensure the integrity of groundwater monitoring data obtained from RFP wells. Forty-six monitoring wells were abandoned and seven replacement wells were installed under WARP during 1992.

RESULTS

Groundwater investigation and restoration activities at RFP follow a five-phase approach to identify contamination, design and implement treatment procedures, and monitor the adequacy of restoration actions. This process includes establishment of groundwater quality standards that are specific to each OU and reflect state and federal requirements. No specific standards have been established for OUs at RFP, although possible limits have been identified pursuant to CERCLA requirements that remedial actions comply with Applicable or Relevant and Appropriate Requirement (ARAR) federal laws or more stringent, promulgated state laws. Site-specific groundwater standards and classifications have been established by the CWQCC. The standards apply to all unconfined groundwater in the alluvial materials,

the Arapahoe aquifer, and the Laramie-Fox Hills aquifer. The alluvial aquifers are classified Domestic and Agricultural Use - Quality and Surface Water Protection. The Arapahoe and Laramie-Fox Hills aquifers are classified Domestic and Agricultural Use - Quality.

The Final IAG (Section 2, "Compliance Summary") divides RFP into 16 OUs for study and restoration. Individual maps of all 16 OUs are located at the end of Section 4, "Remediation." The following sections discuss results of groundwater investigations in OUs 1, 2, 4, 7, and 11.

Operable Unit 1

881 Hillside. The report titled *Draft Final Phase III RFI/RI Report, Rocky Flats Plant, 881 Hillside Area, Operable Unit No. 1* (EG91c) contains information on groundwater quality at OU 1. Field work for the Phase III RI was completed in January 1992. In the OU 1 Phase III RI, 56 boreholes and 39 wells were drilled, and 23 of the wells were completed as monitoring wells. In addition, pump and tracer testing, 5 piezometers, and 11 additional wells around the French drain were completed to further characterize the OU 1 hydrologic systems. Based on the most recently completed Phase III RFI/RI, it is apparent that groundwater contamination posing the most significant public health risk arises from VOCs (i.e., carbon tetrachloride, perchloroethylene, trichloroethylene). These VOCs are historically linked to storage of drums containing cleaning solvents at IHSS 119.1 from 1967 to 1972 (Figure 4-1, Section 4). Figure 3.4-3 shows approximate outlines of the groundwater contaminant plumes on the plantsite and depicts the extent of contaminant movement under the 881 Hillside.

Concentrations of VOCs diminish downgradient of IHSS 119.1, becoming equal to or below detection limits (5 µg/l) within 200 feet of the original storage area. Slightly elevated concentrations of inorganic constituents also were found in the eastern portion of OU 1, where analytes detected above background levels included total dissolved solids (TDS), metals (nickel, strontium, selenium, zinc, and copper), and uranium.

Construction of a French drain and treatment facility for OU 1 were completed, which allowed for treatment of contaminated groundwater to begin in May 1992. The treatment facility houses an ultraviolet (UV) peroxide process to treat organics and an ion exchange system for removal of metals, including uranium.

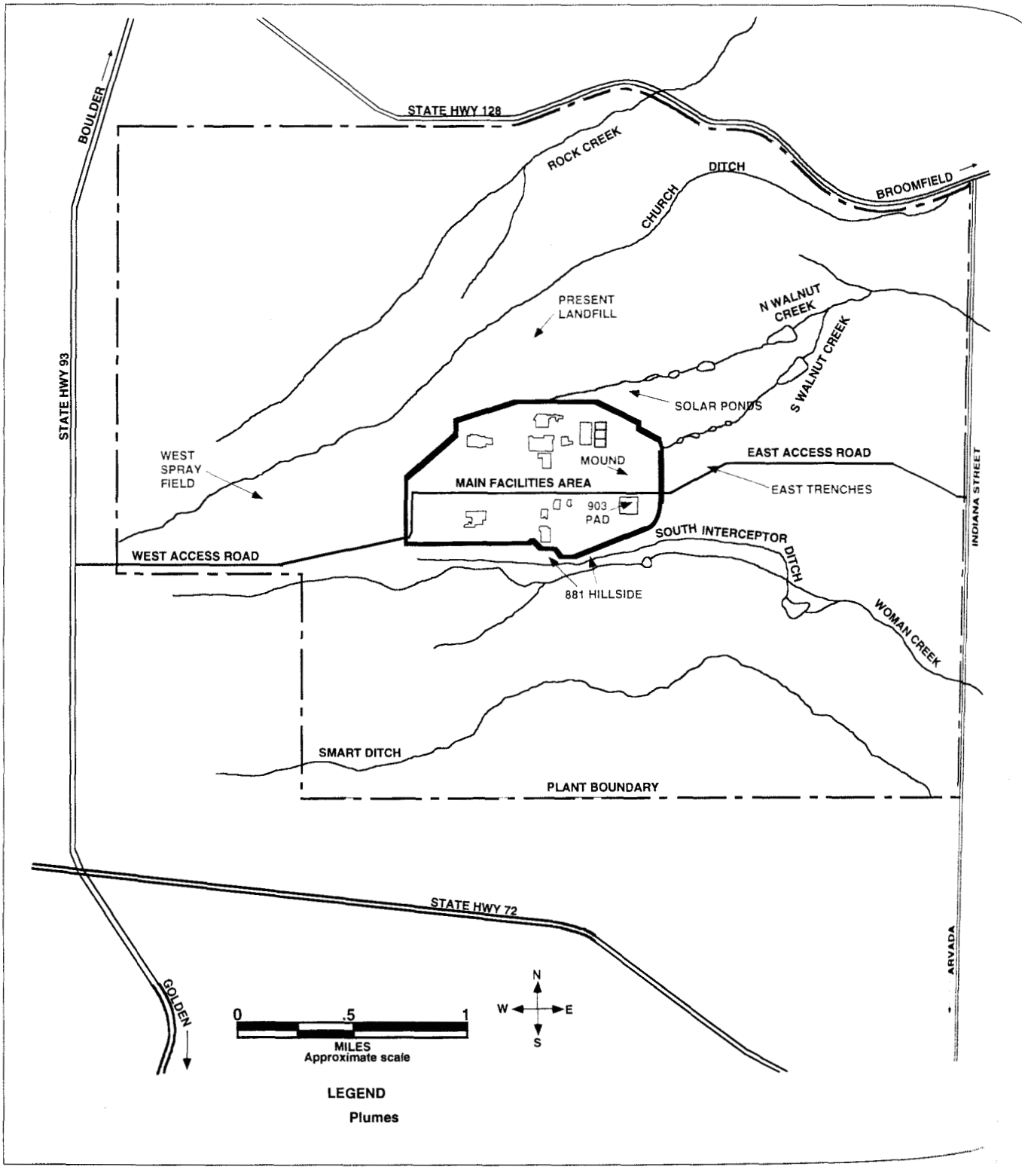


Figure 3.4-3. Location of Known Groundwater Contamination Plumes

Operable Unit 2

903 Pad, Mound, and East Trenches Areas. The report titled *Phase II RFI/RI Work Plan, Rocky Flats Plant, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2* (EG91d) contains information on groundwater quality at OU 2. Groundwater in the upper hydrostratigraphic unit, which is composed of alluvial materials and shallow subcropping sandstones, is contaminated with VOCs, inorganics, dissolved metals, and some radionuclides.

Inorganics and dissolved metals commonly occurring above background levels include TDS, strontium, barium, copper, and nickel, and to a lesser extent, chromium, manganese, selenium, lead, zinc, and molybdenum. The majority of the radionuclide contamination is uranium -238. Americium and plutonium are also present in some groundwater samples.

Contaminants of most concern are VOCs. Those detected include tetrachloroethene, trichloroethene, and carbon tetrachloride. Figure 3.4-3 depicts groundwater contaminant plumes on the plantsite and indicates the approximate extent of contamination at OU 2. Certain inorganic parameters and radionuclides are elevated above background levels in OU 2, but they do not appear to exist as a well-defined plume of contamination. Investigations are continuing to further characterize these plumes and the magnitude and extent of contamination. In the summer of 1992, three aquifer pump tests also were conducted to determine hydrologic characteristics of the alluvium, Number 1 Sandstone, and the bedrock formations.

Operable Units 4, 7, and 11 (RCRA-Regulated Units)

The Solar Evaporation Ponds, Present Landfill, and West Spray Field (OUs 4, 7, and 11). The purpose of groundwater monitoring in these RCRA-regulated units is to assess impacts of waste management activities on groundwater quality in the uppermost aquifer beneath these units. The report titled *1992 Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Plant* (EG93c) presents results of 1992 interim-status quarterly groundwater monitoring. Data are presented for groundwater elevations, flow rates, and quality analyses. A comparison is made between analyte concentrations upgradient of the unit and those downgradient of the unit to evaluate the impact of waste management activities on groundwater quality. The following sections highlight results of groundwater monitoring in each respective unit.

Solar Evaporation Ponds (OU 4). Groundwater assessment monitoring continues to be performed at the Solar Evaporation Ponds area to further assess the levels, extent, and migration characteristics of contamination in the uppermost aquifer beneath this unit. Water elevation data collected throughout 1992 reveals that groundwater flow across the Solar Evaporation Ponds area is generally in an easterly direction, although it diverges along two major subsurface flowpaths. One flowpath is northeasterly toward North Walnut Creek and the other is southeasterly toward South Walnut Creek. There are also large areas where surficial materials are unsaturated. The most prominent of these areas coincides with the location of the Interceptor Trench System, which collects groundwater downgradient of the Solar Evaporation Ponds and diverts it back to one of the ponds. Groundwater flow velocities calculated for surficial materials are between 11 and 36 feet per year. Groundwater elevations are presented in Figure 3.4-4 for surficial materials during the second quarter of 1992.

A statistical comparison of downgradient water quality compared with upgradient groundwater quality indicates that groundwater in downgradient wells screened in the uppermost aquifer north, east, and southwest of the ponds is impacted with nitrate/nitrite, total dissolved solids, fluoride, bicarbonate, sulfate, dissolved radionuclides, and several dissolved metals. Dissolved radionuclides detected in surficial wells downgradient and in the immediate vicinity of the Solar Evaporation Ponds during 1992 included uranium-233, -234 (as high as 136.3 pCi/l), uranium-235, uranium-238 (92.0 pCi/l), and tritium. Total radionuclides detected in the uppermost aquifer include americium-241 (0.40 pCi/l) and plutonium-239, -240 (0.67 pCi/l). Concentrations and distribution of uranium-233, -234, plutonium-239, -240, and americium-241 (reported in pCi/l) in the Solar Evaporation Ponds area are presented in Figure 3.4-5. VOCs detected in surficial wells in the vicinity of the Solar Evaporation Ponds are shown in Figure 3.4-6 and include trichloroethene, tetrachloroethene, carbon tetrachloride, chloroform, and several others.

Present Landfill (OU 7). The Present Landfill is undergoing groundwater monitoring to assess the level, extent, and migration characteristics of contamination in the uppermost aquifer beneath the unit. Groundwater elevation data collected in 1992 indicates that

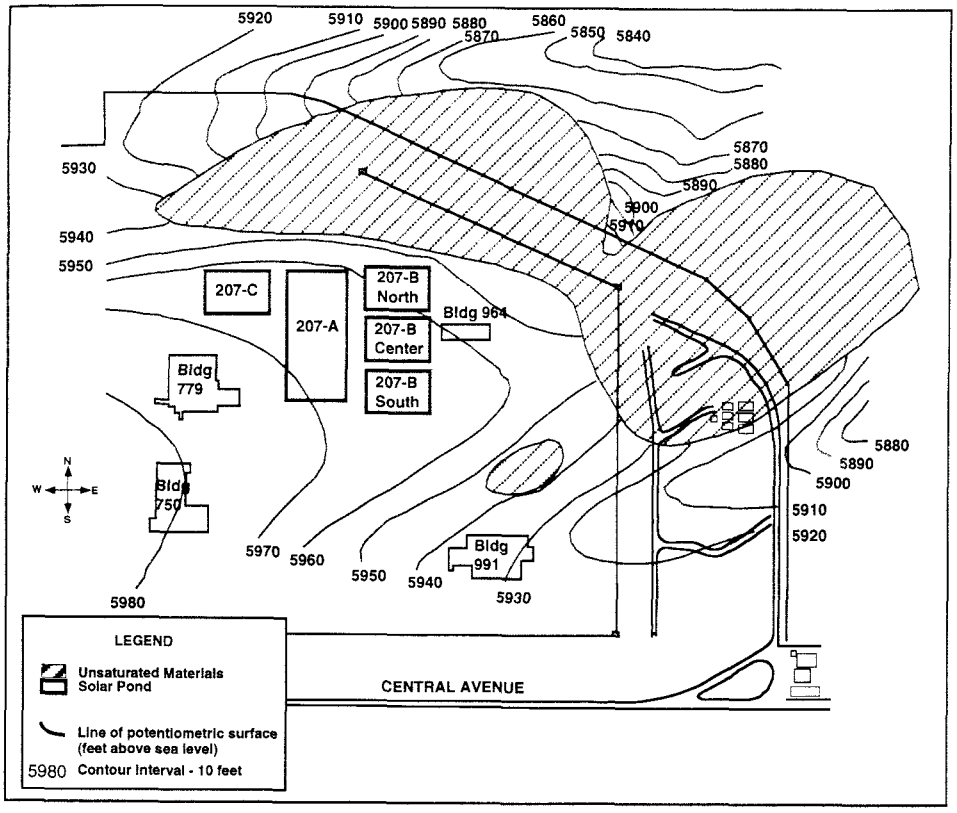


Figure 3.4-4. Solar Evaporation Ponds Potentiometric Surface in Surficial Materials

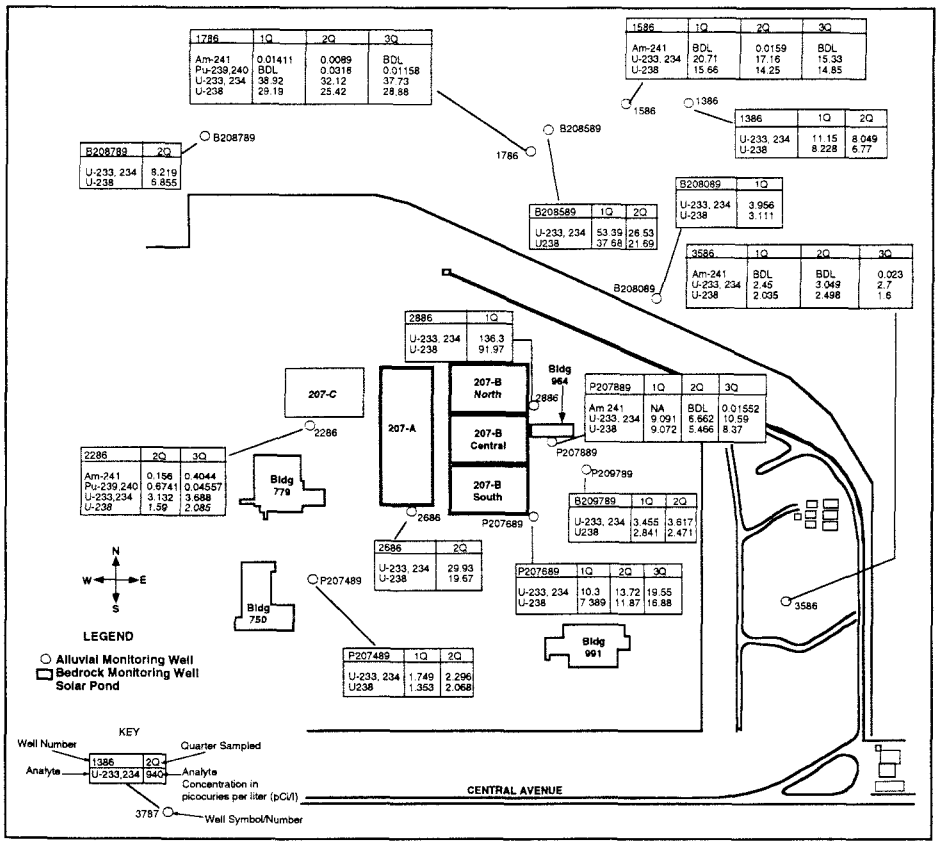


Figure 3.4-5. Solar Evaporation Ponds Dissolved Uranium-233, -234, Plutonium-239, -240, and Americium-241 Detected in the Uppermost Aquifer

groundwater beneath the landfill tends to flow easterly through surficial geologic materials toward the landfill pond. This flow, as recorded in the second quarter 1992, is illustrated in Figure 3.4-7. Close to the pond, groundwater flows southeasterly and northeasterly toward the pond. Flow velocities have been calculated at 133 to 142 feet per year for groundwater in surficial materials. Groundwater flow characteristics in the weathered bedrock are similar to those observed in the overlying surficial materials, although groundwater flow in these materials is much slower at 0.2 to 0.9 feet per year. Influencing the natural flow of groundwater and surface water in the area are several engineering control systems installed to intentionally redirect flow around the landfill. Engineering control systems include pond embankments, a leachate/groundwater intercept system, a surface water interceptor ditch, and a buried slurry wall.

Assessment of the 1992 data suggests that groundwater outside of the landfill is diverted around the landfill wastes and discharged into the landfill pond. Landfill contaminants migrate with the groundwater flow through the leachate collection system toward the landfill pond. Water is retained within the pond, where it either evaporates directly or is evaporated by spray irrigation onto the hillsides adjacent to the pond. Data from 1992 suggest that the groundwater intercept system may not be diverting all groundwater away from the north and south sides of the landfill, and the leachate collection system may function intermittently on the north side of the landfill.

Shallow surficial and deep bedrock groundwater wells are monitored quarterly at the Present Landfill. Groundwater quality data in downgradient wells statistically compared with those upgradient of the landfill in 1992 show that the landfill contributes several dissolved metals, dissolved radionuclides, and inorganic analytes to the uppermost aquifer downgradient of the landfill. Specifically, the landfill is observed to impact groundwater quality through increased concentrations of bicarbonate, calcium, chloride, fluoride, magnesium, sodium, and total dissolved solids. Additionally, the landfill appears to contribute antimony, chromium, lithium, potassium, strontium, arsenic, barium, manganese, and vanadium. Gross alpha and gross beta activities were also statistically higher in downgradient wells than in upgradient wells, in addition to uranium-235 and uranium-233, -234. No VOCs were detected in the uppermost aquifer downgradient of the landfill in 1992.

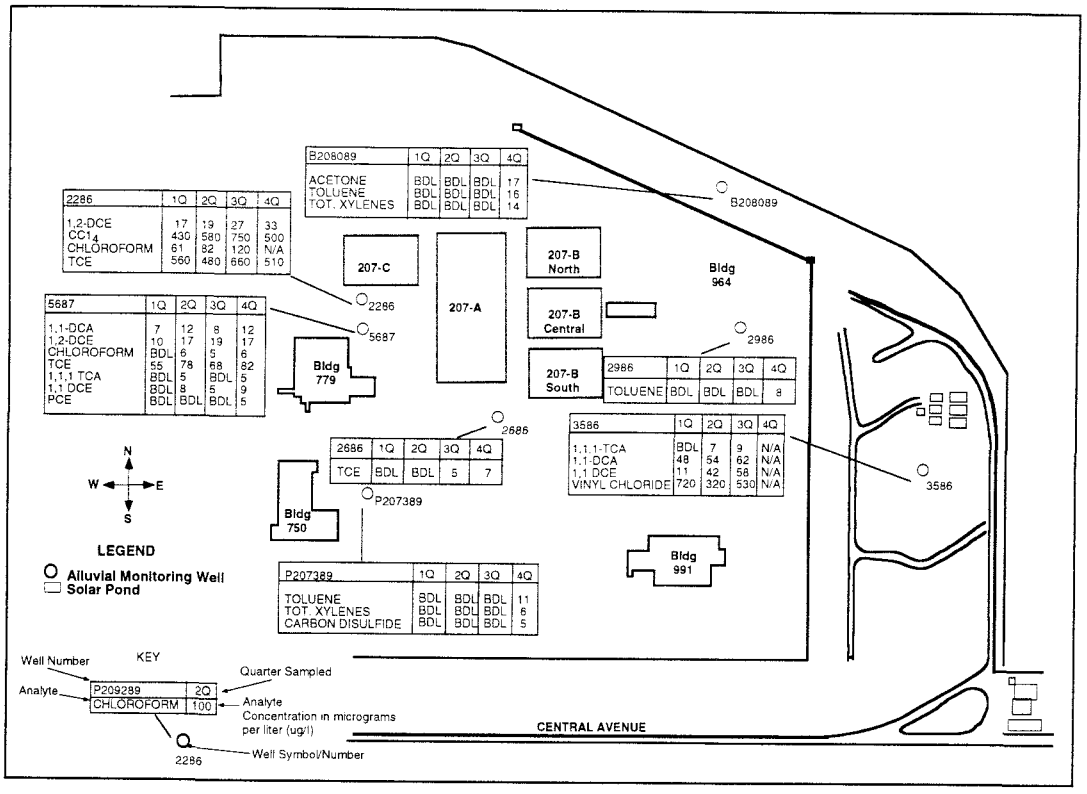


Figure 3.4-6. Solar Evaporation Ponds Volatile Organic Compounds Detected in the Uppermost Aquifer

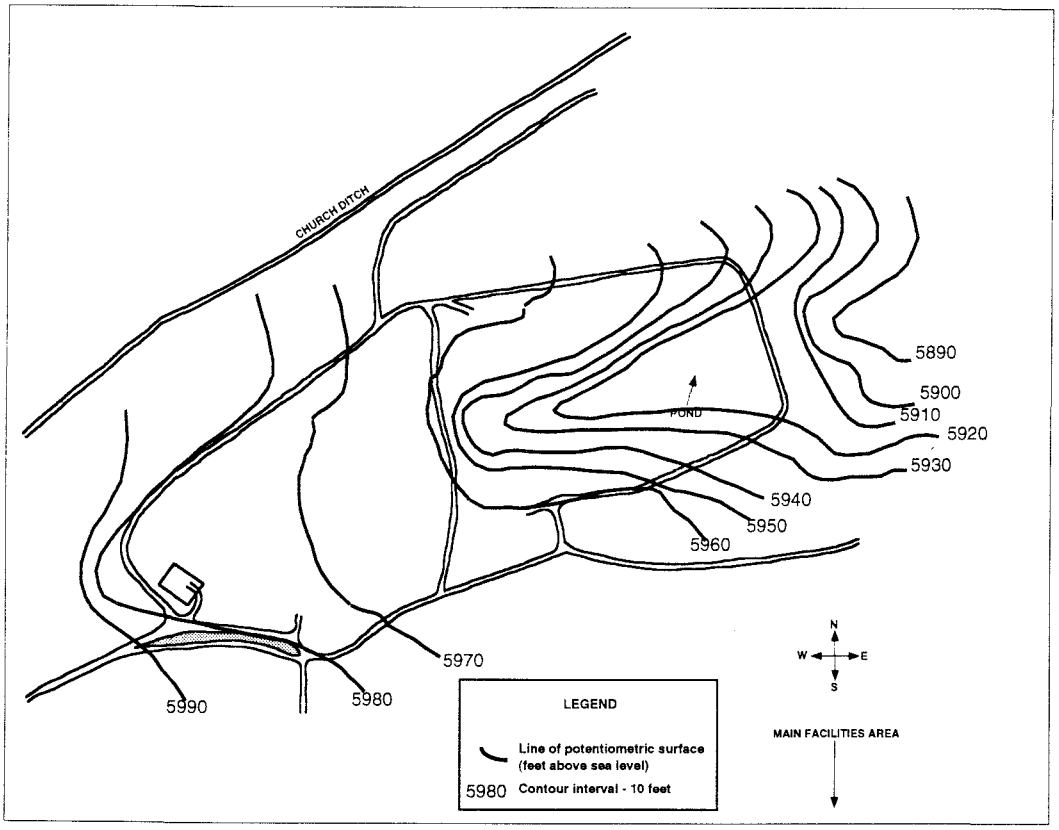


Figure 3.4-7. Present Landfill Potentiometric Surface in Surficial Materials

Within the confines of the Present Landfill, the nature of groundwater contamination is characterized by the detection of VOCs, radionuclides, and concentrations of metals and inorganic analytes higher than in upgradient wells. Dissolved radionuclides detected in 1992 in and adjacent to the landfill include tritium (up to 1.629 pCi/l), strontium-89, -90 (1.597 pCi/l), uranium-233, -234 (19.74 pCi/l), uranium-235 (0.72 pCi/l), and uranium-238 (16.09 pCi/l). Total radionuclides detected include americium-241 (0.06 pCi/l), and plutonium-239, -240 (up to 0.44 pCi/l). Radionuclides were detected in a wide area across the landfill site. Figure 3.4-8 shows the distribution and concentration of radionuclides at the landfill with concentrations given in pCi/l. Detection of VOCs during 1992 occurred primarily in wells in the southern portion of the landfill. A number of different compounds were detected including carbon tetrachloride, trichloroethene, tetrachloroethene, and others. The distribution and concentrations (reported in µg/l) of detected VOCs are presented in Figure 3.4-9.

West Spray Field (OU 11). Groundwater monitoring at the West Spray Field is conducted to provide data for assessment of the level, extent, and migration characteristics of contamination in the uppermost aquifer beneath this unit. Groundwater flow in the uppermost aquifer is relatively uniform and occurs in an east-northeasterly direction. Groundwater flow rates were calculated at 49 feet to 73 feet per year in 1992. Alluvial wells and bedrock wells are routinely sampled at the West Spray Field. A potentiometric surface map showing groundwater elevations in the uppermost aquifer is presented for the second quarter of 1992 in Figure 3.4-10.

Groundwater quality in the uppermost aquifer in downgradient wells was statistically compared with that in upgradient wells. This comparison revealed that concentrations of several analytes were higher in downgradient wells than in wells upgradient of the West Spray Field. Those analytes included gross alpha, uranium-233, -234, calcium, sodium, vanadium, chloride, fluoride, silicon, and pH.

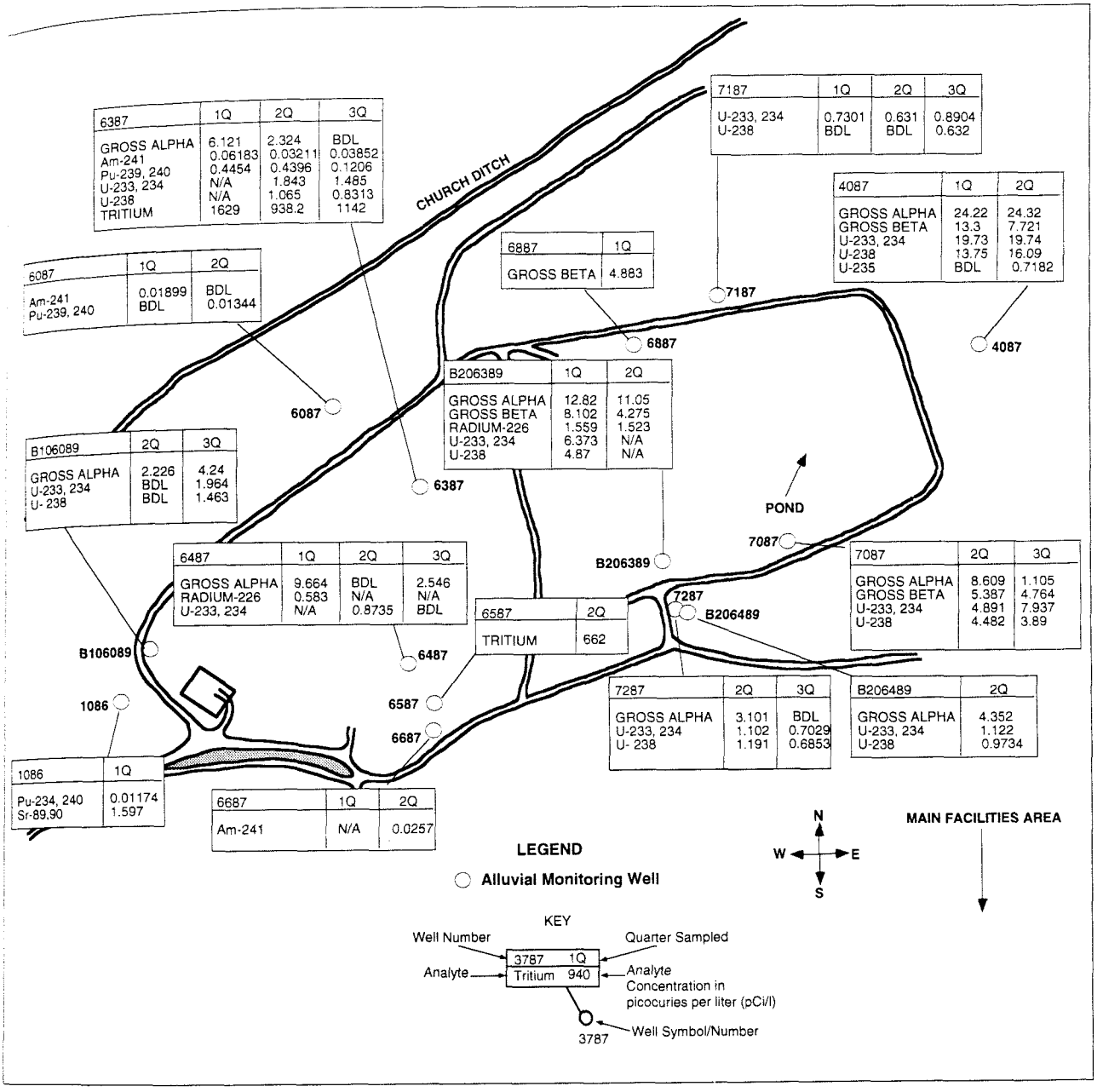


Figure 3.4-8. Present Landfill Radionuclides in the Uppermost Aquifer

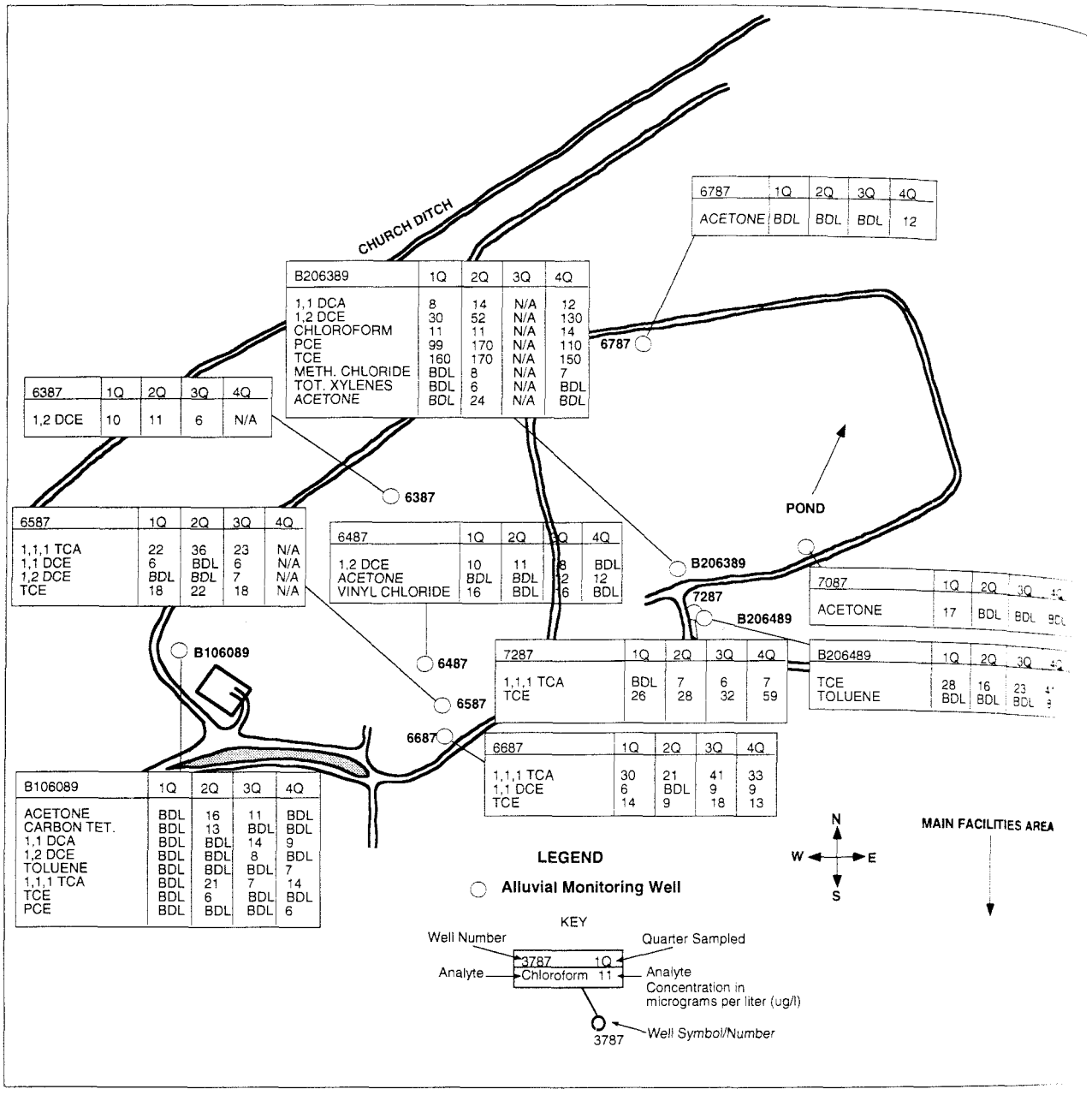


Figure 3.4-9. Present Landfill Volatile Organic Compounds Detected in the Uppermost Aquifer

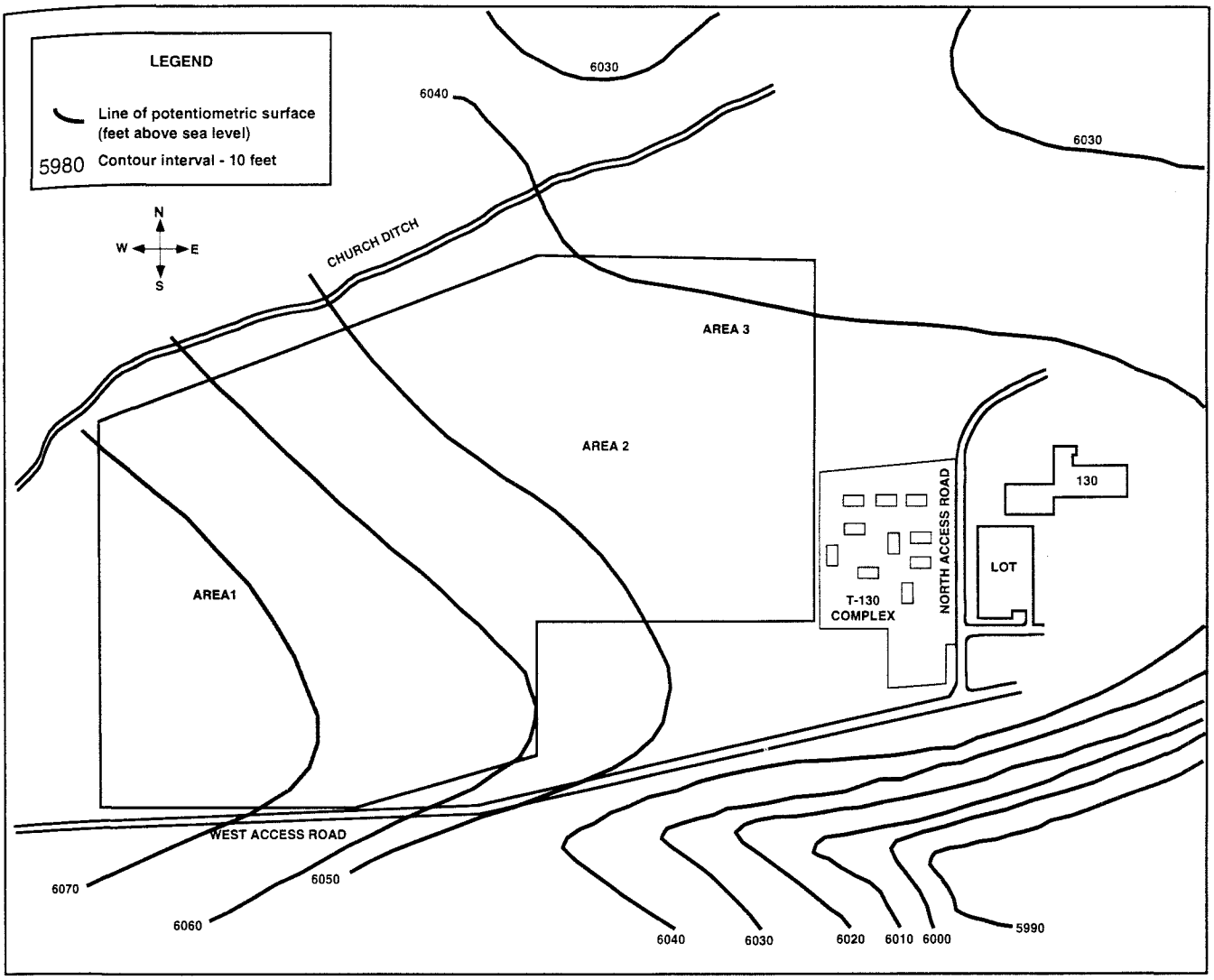


Figure 3.4-10. West Spray Field Potentiometric Surface in Surficial Materials

Within and adjacent to the West Spray Field, groundwater quality has been impacted by dissolved radionuclides, a few dissolved metals, and inorganic analytes. Dissolved radionuclides detected include uranium-233, -234 (at 1.39 pCi/l), and uranium-238 (0.83 pCi/l). Total radionuclides in the uppermost aquifer within the West Spray Field include americium-241 (0.088 pCi/l) and plutonium-239 (0.25 pCi/l). The distribution and concentrations of radionuclides (reported in pCi/l) detected during 1992 in the uppermost aquifer are shown in Figure 3.4-11.

Inorganic analytes detected at elevated levels within the West Spray Field include fluoride, chloride, bicarbonate, sodium, sulfate, nitrate/nitrite, orthophosphate, and total suspended solids. Assessments made in 1992 conclude that waste management activities did contribute to the presence of these inorganic compounds at the West Spray Field.

Boundary Wells

Groundwater quality is monitored quarterly in a series of wells downgradient of RFP, along the plant's eastern boundary at Indiana Street. Nine boundary wells are routinely sampled to measure water quality in three separate hydrostratigraphic units. These include the valley-fill alluvium, colluvium, and the sandstones, siltstones, and claystones of the Arapahoe and Laramie Formations. Laboratory results from samples collected during 1992 were compared with background upper tolerance limits that had been previously calculated for each of the three hydrostratigraphic units. Results of water quality analyses for VOCs, Dissolved Metals of Interest, and Total Radionuclides are provided in Tables 3.4-3, 3.4-4, and 3.4-5, respectively.

Valley-fill alluvium groundwater is monitored by four wells (#0186, #0486, #41491, and #41691). VOCs were detected in several of the wells. Among the detected compounds were acetone and methylene chloride, which are considered laboratory contaminants because of their presence in blanks. In well #41491, located in the Woman Creek drainage, several other compounds (TCE, PCE, and carbon tetrachloride) were detected at levels just exceeding detection limits. These values are not indicative of historical surface water analyses. Some dissolved metals (cadmium, lead, and cobalt) were measured at levels just above the detection limit.

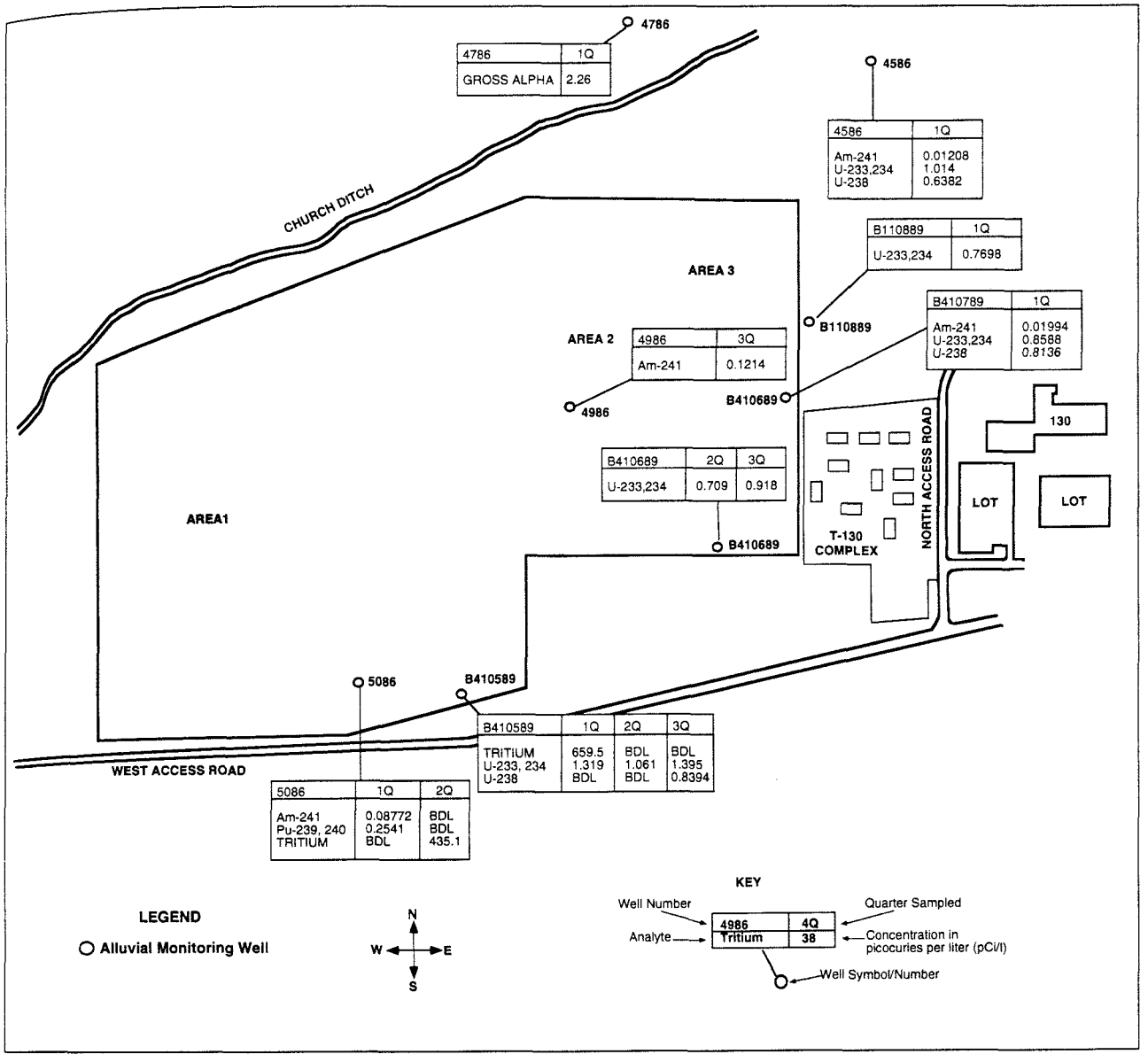


Figure 3.4-11. West Spray Field Radionuclides Detected in the Uppermost Aquifer

Table 3.4-3
Volatile Organic Compounds Detected in Boundary Wells

Well Number	Analyte Sampled	Result (µg/l)	Detection Limit (µg/l)
Valley-fill Alluvium			
41491[b]	Carbon Tetrachloride	0.18	0.02
41491	Methylene Chloride	5.3	0.01
41491[a]	PCE	0.2	0.02
41491[a,b]	TCE	0.08	0.03
41491	PCE	1.2	0.02
Arapahoe/Laramie Formation			
0386	Acetone	18	10
06491[b]	Toluene	0.17	0.02
06491[a]	Methylene Chloride	1	0.6

a. Indicates the compound was found in the blank and the sample.
b. Indicates an estimated value for either a tentatively identified compound or an analyte that meets the identification criteria, but the result is less than the specified detection limit.

Table 3.4-4
Dissolved Metals of Interest Detected in Boundary Wells

Well Number	Analyte Sampled	Result (µg/l)	Detection Limit (µg/l)
Valley-fill Alluvium			
0486[a,c]	Cadmium	3.8	2.3
41691	Lead	1.7	0.8
41691	Cobalt	3.1	2.7
Arapahoe/Laramie Formation			
0386[a]	Selenium	50.8	5.0
0386	Selenium	57.5	8.5
0386[a]	Selenium	59.8	5.0
0386	Selenium	64.5	5.0
06491	Arsenic	0.8	0.7
06491	Lead	1.1	1.0
B217289	Arsenic	1.2	0.7
Colluvium			
41591	Arsenic	1.1	0.7

a. Reported value was determined by method of standard additions.
b. Indicates an estimated value for either a tentatively identified compound or an analyte that meets the identification criteria, but the result is less than the specified detection limit.
c. Acceptable with qualifications.

Table 3.4-5
Total Radionuclides Greater Than Background Upper Tolerance Limits Detected in Boundary Wells

	Well Number	Analyte Sampled	Result (pCi/l)	Error Factor	Detection Limit (pCi/l)
Valley-fill Alluvium					
	0486[a,c]	Plutonium-239, -240	0.1848	±0.0766	0.01
	0486[a,c]	Americium-241	0.03908	±0.0223	0.01
	41691[b,d]	Americium-241	0.2198	±0.0506	0.01
	41691[b,d]	Plutonium-239, -240	1.2960	±0.182	0.005
	41691[a,c]	Americium-241	0.0804	±0.0235	0.01
	41691[a,c]	Plutonium-239, -240	0.6774	±0.134	0.01
Colluvium					
	0286[b]	Plutonium-239, -240	0.0769	±0.0296	0.01

a. Qualifier = Not available.
b. Qualifier = Result is by calculation. Solid and dissolved phase are analyzed separately and results are added to determine activity.
c. Validation Code = Not available.
d. Validation Code = Acceptable with qualifications.

No dissolved radionuclides were detected above background upper tolerance limits. However, total (dissolved plus suspended) plutonium-239, -240 and total americium-241 were measured at activities above background upper tolerance limits in two wells (#0486 and #41691). The highest reported activity was plutonium-239, -240 at 1.3 pCi/l in well #41691. An independent quality control check on this result concluded that it is acceptable with qualifications (Validation Code is provided in the footnotes of Table 3.4-5). Results were calculated by the laboratory in two cases (Lab Qualifier in Table 3.4-5). Wells #0486 and #41691 are screened in the shallow valley-fill alluvium (from approximately 4 to 15 feet below the surface) and are located next to one another in the Walnut Creek drainage. Both of these wells exhibited relatively high total suspended solids during 1992 (150 to 1,100 mg/l in well #0486 and 910 to 3,300 mg/l in well #41691). High suspended solids are found in well #41691 because it was recently installed, and well development, a process in which fine suspended materials are winnowed out of the gravel pack surrounding the well by vigorous pumping, is not complete. Low levels of plutonium-239, -240 are known to exist in sediment along this reach of Walnut Creek. The plutonium detected in wells #0486 and #41691 is believed to be associated with the stream sediments that may have been a source of the high suspended solids found in the wells.

Groundwater quality in the colluvium is monitored in two boundary wells (#0286 and #41591). No VOCs were detected in samples of colluvial groundwater. The only dissolved metal of interest detected was arsenic in well #41591 at slightly above the detection limit. No dissolved radionuclides were detected above background upper tolerance limits in the colluvium. Total plutonium -239, -240 was detected in well #0286 at 0.0769 pCi/l. These results suggest that groundwater in the colluvium is unaffected by RFP activities.

Wells #0386, #06491, and #B217289 monitor groundwater contained in the Arapahoe and Laramie Formation sandstones, siltstones, and claystones. Toluene was detected at 0.17 µg/l in well #06491. No other VOCs were detected in samples from the Arapahoe/ Lamarie Formation. Several dissolved metals, including selenium, arsenic, and lead, were detected at levels just above the detection limit. Selenium is naturally occurring, and measurable levels in well #0386 may represent natural differences in concentrations at different locations. Several dissolved radionuclides, including isotopes of uranium and gross alpha, were measured at activities above background upper tolerance limits. Detections of dissolved radionuclides in the deeper hydrostratigraphic units may reflect the variability of uranium concentrations in natural materials and not represent contamination. Water-quality results for Arapahoe and Laramie Formation materials suggest that operations at RFP have not impacted these hydrostratigraphic units, and that detections of metals and radionuclides reflect natural variability within native materials.

Results of groundwater monitoring in the Indiana Street boundary wells during 1992 suggest that RFP activities have had little effect on groundwater quality along the eastern border of RFP. VOCs and dissolved metals of concern that were detected in the valley-fill alluvium, colluvium, and Arapahoe and Laramie Formations exhibited concentrations only slightly above detection limits. Radionuclides detected in boundary wells along Walnut Creek are believed to be associated with high suspended solids in those wells derived from stream sediments. There is no direct hydraulic connection between this shallow alluvial aquifer and deeper aquifers in the Denver Basin used for domestic water supplies. Continued quarterly monitoring of boundary wells will be performed and results will be used to assess potential changes in concentrations for analytes of interest.

3.5 Soil Monitoring

Michael Z. Litaor

Soil Monitoring at Rocky Flats is conducted annually to evaluate any changes in plutonium concentrations that might occur through soil resuspension or other mechanisms, and to compare plutonium concentrations in soils on an annual basis. The data acquired from soil sampling are provided in this section.

OVERVIEW

The Soil Monitoring Program at RFP has been conducted since 1972, with the exception of the years 1978 through 1983. Soils were sampled at RFP in November 1992 at 40 sites located within concentric circles, approximately 1.6- and 3.2-km radii (1 and 2 miles) from the center of RFP (Figure 3.5-1). Along each circle, sampling locations were spaced at 18° increments and designated accordingly (e.g., location 1-018 refers to the inner circle [#1] at 18° northeast). The soil samples were collected by driving a 10- by 10-centimeter (4- by 4-inch) cutting tool 5 centimeters (2 inches) deep into undisturbed soil. The soil sample within the tool cavity was collected and placed into a new 1-gallon stainless steel can. Five subsamples were collected from the corners and the center of the two 1-meter squares, which were spaced 1 meter apart. Each set of 10 subsamples was composited (5,000 cubic centimeters [cm^3]) for soil radionuclides analysis. Laboratory analysis was performed to determine the plutonium concentration, expressed as picocuries per gram (pCi/g).

RESULTS

Soil plutonium concentrations for 1984 through 1992 are presented in Table 3.5-1. Figure 3.5-1 depicts the location of the soil sample sites, as well as the mean and standard deviation of soil plutonium concentrations from 1984 through 1992. Samples taken in 1992 from the inner concentric circle ranged from 0.03 pCi/g to 11.0 pCi/g. In previous years, the highest soil plutonium concentration was found at sites 1-090 and 1-108 (Figure 3.5-1). Since the 1990 annual soil sampling, the site at 1-090 has been relocated approximately 200 meters to the north. The older site is located in an area currently under intensive study as part of the IAG.

Samples from the outer concentric circle ranged from 0.01 pCi/g to 8.8 pCi/g. The highest plutonium concentrations were found in soil samples taken from the eastern portion of the buffer zone. These sample locations are east and southeast of the major source of plutonium contamination in the soil environment at RFP. It is believed that plutonium contamination probably originated from the area known as the 903 Pad (OU 2), where steel drums were used to store plutonium-contaminated industrial oils from 1958 to 1968. Leakage from these drums contaminated surface soils and

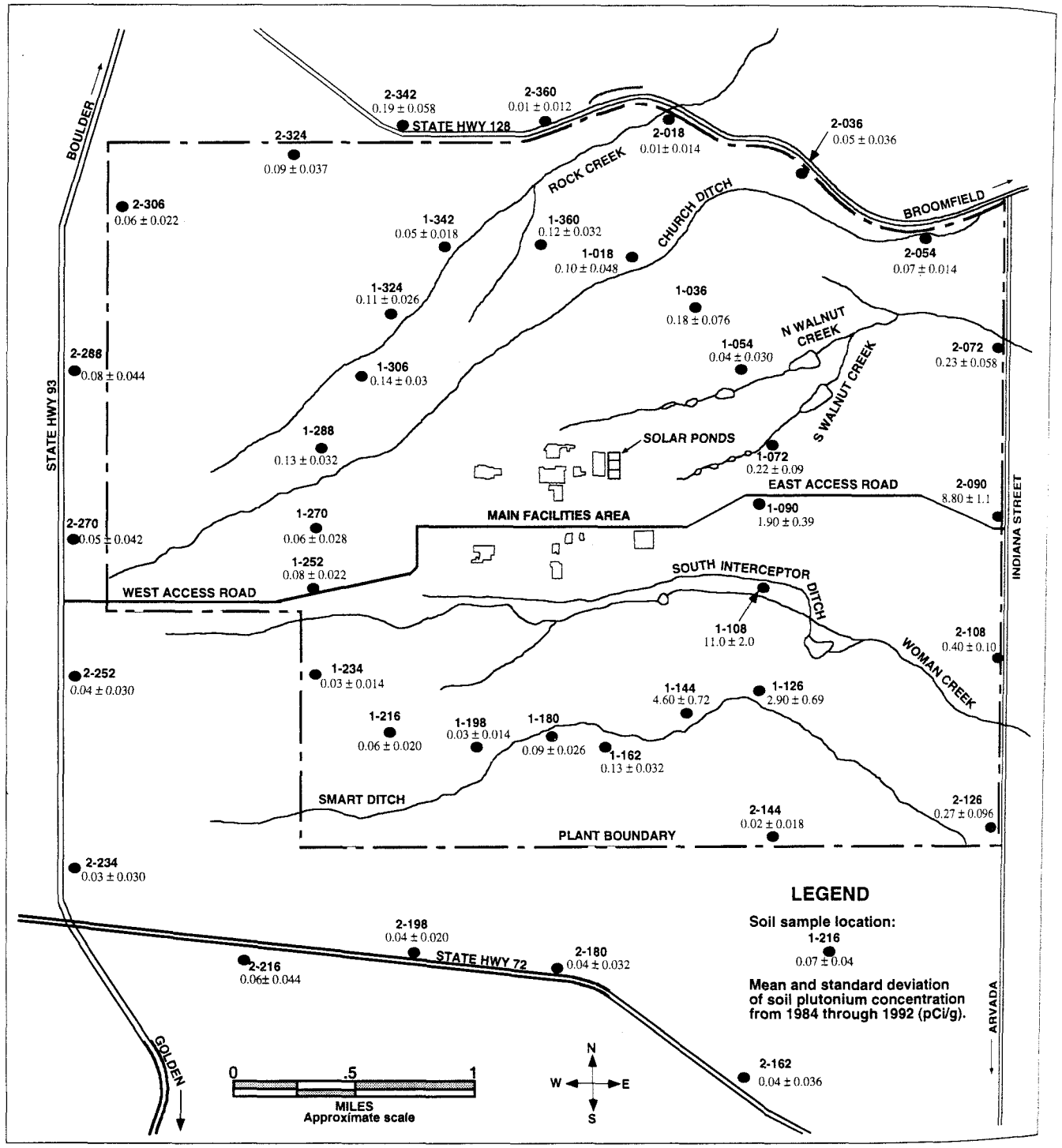


Figure 3.5-1. Soil Sampling Locations

plants. Plutonium particles entrapped in the fine fraction of top soil horizons were subsequently airlifted by winds and deposited on soils in an east and southeast-trending plume (KR70). Table 3.5-1 indicates that data from previous years have consistently shown elevated plutonium concentrations in soils from these sites.

The plutonium concentrations in soils east and southeast of the 903 Pad Area varied somewhat between years. Each monitoring site was adequately sized (30 by 30 meters) to allow annual selection of nonoverlapping sample areas. Since the sampling location varied between years, small microtopographical variation was introduced, which affected wind deposition and resuspension rates of plutonium. In addition, natural variability in erosional and faunal activities, as well as sampling and analytical error, contribute to the observed variability. Other investigators (PI80) have observed high variability in soil plutonium concentrations in other contaminated sites, especially near the release source. Investigators ascribed these variations in plutonium-239, -240 to varying distance from point of release (75 percent), microtopographical variations (20 percent), and sampling error, which included subsampling and analytical error (5 percent). Variability in plutonium concentrations in soils taken from the two radial grids at 18° to 36° and 162° to 360° was extremely small.

Table 3.5-1
Plutonium Concentration in Soil Samples at 1 and 2 Miles from the Plant Center

Inner Circle:

Location	1984 Pu pCi/g[a,b,c,d]	1985 Pu pCi/g[a,b,c,d]	1986 Pu pCi/g[a,b,c,d]	1987 Pu pCi/g[a,b,c,d]
1-018	0.08 ± 0.02	0.15 ± 0.02d	0.15 ± 0.02	0.18 ± 0.02
1-036	0.03 ± 0.01	0.08 ± 0.01	0.10 ± 0.02	0.06 ± 0.01
1-054	0.00 ± 0.01	0.02 ± 0.01	0.04 ± 0.01	0.04 ± 0.01
1-072	0.6 ± 0.05	0.32 ± 0.03	0.63 ± 0.06	0.51 ± 0.05
1-090	7.7 ± 0.5	1.00 ± 0.09	7.40 ± 0.62	7.05 ± 0.77
1-108	15.0 ± 0.9	13.0 ± 1.30	15.0 ± 1.40	2.37 ± 0.21
1-126	2.1 ± 0.1	1.90 ± 0.17	1.90 ± 0.18	2.75 ± 0.28
1-144	0.29 ± 0.03	0.32 ± 0.03	0.27 ± 0.02	0.36 ± 0.04
1-162	0.14 ± 0.02	0.10 ± 0.01	0.08 ± 0.01	0.17 ± 0.02
1-180	0.09 ± 0.02	0.06 ± 0.01	0.06 ± 0.01	0.10 ± 0.01
1-198	0.22 ± 0.03	0.16 ± 0.02	0.16 ± 0.02	0.21 ± 0.02
1-216	0.05 ± 0.02	0.05 ± 0.01	0.10 ± 0.01	0.16 ± 0.02
1-234	0.13 ± 0.02	0.05 ± 0.01	0.04 ± 0.01	0.05 ± 0.01
1-252	0.17 ± 0.02	0.14 ± 0.02	0.11 ± 0.01	0.21 ± 0.03
1-270	0.06 ± 0.02	0.07 ± 0.01	0.08 ± 0.01	0.09 ± 0.01
1-288	0.04 ± 0.01	0.05 ± 0.01	0.05 ± 0.01	0.06 ± 0.01
1-306	0.14 ± 0.02	0.09 ± 0.01	0.17 ± 0.02	0.21 ± 0.03
1-324	0.13 ± 0.02	0.15 ± 0.02	0.21 ± 0.02	0.24 ± 0.03
1-342	0.04 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.03 ± 0.01
1-360	0.10 ± 0.02	0.11 ± 0.01	0.19 ± 0.02	0.16 ± 0.02

Outer Circle:

2-018	0.00 ± 0.01	0.04 ± 0.01	0.03 ± 0.01	0.04 ± 0.01
2-036	0.02 ± 0.01	0.02 ± 0.01	0.07 ± 0.01	0.10 ± 0.01
2-054	0.03 ± 0.01	0.03 ± 0.01	0.05 ± 0.01	0.10 ± 0.01
2-072	0.4 ± 0.04	0.33 ± 0.03	0.23 ± 0.02	0.36 ± 0.04
2-090	10.0 ± 0.6	2.50 ± 0.25	5.30 ± 0.48	4.48 ± 0.52
2-108	0.46 ± 0.04	0.41 ± 0.04	0.46 ± 0.04	0.57 ± 0.06
2-126	0.14 ± 0.02	0.42 ± 0.04	0.44 ± 0.05	0.40 ± 0.04
2-144	0.02 ± 0.01	0.04 ± 0.01	0.04 ± 0.01	0.08 ± 0.01
2-162	0.00 ± 0.01	0.01 ± 0.00	0.02 ± 0.01	0.03 ± 0.01
2-180	0.02 ± 0.01	0.11 ± 0.01	0.04 ± 0.01	0.03 ± 0.01
2-198	0.05 ± 0.02	0.02 ± 0.01	0.08 ± 0.01	0.14 ± 0.02
2-216	0.04 ± 0.01	0.04 ± 0.01	0.06 ± 0.01	0.07 ± 0.01
2-234	0.04 ± 0.01	0.05 ± 0.01	0.05 ± 0.01	0.07 ± 0.01
2-252	0.09 ± 0.01	0.04 ± 0.01	0.07 ± 0.01	0.06 ± 0.01
2-270	0.04 ± 0.01	0.04 ± 0.01	0.06 ± 0.01	0.08 ± 0.01
2-288	0.01 ± 0.01	0.04 ± 0.01	0.05 ± 0.01	0.13 ± 0.02
2-306	0.00 ± 0.01	0.06 ± 0.01	0.02 ± 0.01	0.08 ± 0.01
2-324	0.08 ± 0.02	0.04 ± 0.01	0.09 ± 0.01	0.08 ± 0.01
2-342	0.13 ± 0.02	0.13 ± 0.01	0.12 ± 0.01	0.14 ± 0.02
2-360	0.02 ± 0.01	0.09 ± 0.01	0.05 ± 0.01	0.08 ± 0.01

a. Not blank corrected.
b. Samples to a depth of 5 cm.
c. Concentrations are for the fraction of soil measuring less than 2 mm diameter.
d. Error term represents two standard deviations.

Table 3.5-1 (Continued)

Plutonium Concentration in Soil Samples at 1 and 2 Miles from the Plant Center

Inner Circle:

Location	1988 Pu pCi/g[a,b,c,d]	1989 Pu pCi/g[a,b,c,d]	1990 Pu pCi/g[a,b,c,d]	1991 Pu pCi/g[a,b,c,d]	1992 Pu pCi/g[a,b,c,d]
1-018	0.10 ± 0.01	0.08 ± 0.01	0.07 ± 0.02	0.13 ± 0.02	0.10 ± 0.048
1-036	0.88 ± 0.01	0.08 ± 0.01	0.07 ± 0.001	0.25 ± 0.05	0.18 ± 0.076
1-054	0.03 ± 0.01	0.13 ± 0.02	0.04 ± 0.01	0.06 ± 0.01	0.04 ± 0.030
1-072	0.37 ± 0.04	0.16 ± 0.02	0.21 ± 0.03	0.18 ± 0.03	0.22 ± 0.09
1-090	10.6 ± 0.98	2.52 ± 0.27	2.18 ± 0.21	1.49 ± 0.23	1.90 ± 0.39
1-108	10.4 ± 0.94	8.56 ± 0.81	9.14 ± 0.12	9.76 ± 1.35	11.00 ± 2.0
1-126	1.55 ± 0.14	1.08 ± 0.13	1.46 ± 0.17	2.13 ± 0.32	2.90 + 0.69
1-144	0.20 ± 0.02	0.12 ± 0.01	0.17 ± 0.02	0.19 ± 0.03	4.60 ± 0.72
1-162	0.09 ± 0.01	0.06 ± 0.01	0.06 ± 0.01	0.09 ± 0.02	0.13 ± 0.032
1-180	0.06 ± 0.01	0.08 ± 0.01	0.04 ± 0.001	0.04 ± 0.01	0.09 ± 0.026
1-198	0.10 ± 0.01	0.05 ± 0.01	0.13 ± 0.005	0.17 ± 0.04	0.03 ± 0.014
1-216	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.007	0.05 ± 0.02	0.06 ± 0.020
1-234	0.05 ± 0.01	0.05 ± 0.01	0.03 ± 0.007	0.05 ± 0.01	0.03 ± 0.014
1-252	0.09 ± 0.01	0.08 ± 0.01	0.07 ± 0.01	0.09 ± 0.02	0.08 ± 0.022
1-270	0.07 ± 0.01	0.06 ± 0.01	0.05 ± 0.01	0.08 ± 0.02	0.06 ± 0.028
1-288	0.03 ± 0.01	0.06 ± 0.01	0.07 ± 0.01	0.09 ± 0.02	0.13 ± 0.032
1-306	0.12 ± 0.01	0.10 ± 0.01	0.08 ± 0.01	0.09 ± 0.02	0.14 ± 0.03
1-324	0.16 ± 0.02	0.07 ± 0.01	0.09 ± 0.01	0.14 ± 0.03	0.11 ± 0.026
1-342	0.02 ± 0.01	0.04 ± 0.01	0.05 ± 0.008	0.05 ± 0.02	0.05 ± 0.018
1-360	0.12 ± 0.02	0.08 ± 0.01	0.11 ± 0.01	0.1 ± 0.02	0.12 ± 0.032
Outer Circle:					
2-018	0.02 ± 0.00	0.02 ± 0.01	0.00 ± 0.003	0.01 ± 0.00	0.01 ± 0.014
2-036	0.07 ± 0.01	0.04 ± 0.01	0.05 ± 0.01	0.06 ± 0.01	0.05 ± 0.036
2-054	0.03 ± 0.01	0.06 ± 0.01	0.18 ± 0.03	0.07 ± 0.01	0.07 ± 0.014
2-072	0.11 ± 0.01	0.46 ± 0.06	0.14 ± 0.02	0.14 ± 0.02	0.23 ± 0.058
2-090	7.12 ± 0.67	1.94 ± 0.23	3.94 ± 0.5	3.61 ± 0.45	8.80 ± 1.1
2-108	0.47 ± 0.05	0.53 ± 0.06	0.32 ± 0.04	0.06 ± 0.07	0.40 ± 0.10
2-126	0.03 ± 0.01	0.28 ± 0.04	0.20 ± 0.02	0.25 ± 0.05	0.27 ± 0.096
2-144	0.35 ± 0.03	0.03 ± 0.01	0.02 ± 0.005	0.04 ± 0.00	0.02 ± 0.018
2-162	0.02 ± 0.01	0.02 ± 0.01	0.01 ± 0.004	0.03 ± 0.00	0.04 ± 0.036
2-180	0.03 ± 0.01	0.08 ± 0.01	0.03 ± 0.007	0.05 ± 0.01	0.04 ± 0.032
2-198	0.10 ± 0.01	0.01 ± 0.01	0.05 ± 0.01	0.07 ± 0.01	0.04 ± 0.020
2-216	0.07 ± 0.01	0.07 ± 0.01	0.04 ± 0.007	0.05 ± 0.01	0.06 ± 0.044
2-234	0.03 ± 0.01	0.05 ± 0.01	0.04 ± 0.002	0.04 ± 0.01	0.03 ± 0.030
2-252	0.04 ± 0.01	0.04 ± 0.01	0.04 ± 0.007	0.04 ± 0.01	0.04 ± 0.030
2-270	0.06 ± 0.01	0.06 ± 0.01	0.04 ± 0.007	0.03 ± 0.01	0.05 ± 0.042
2-288	0.07 ± 0.01	0.08 ± 0.01	0.03 ± 0.006	0.03 ± 0.00	0.08 ± 0.044
2-306	0.02 ± 0.00	0.04 ± 0.01	0.06 ± 0.01	0.08 ± 0.01	0.06 ± 0.022
2-324	0.14 ± 0.02	0.06 ± 0.01	0.09 ± 0.01	0.08 ± 0.01	0.09 ± 0.037
2-342	0.10 ± 0.01	0.06 ± 0.01	0.10 ± 0.01	0.1 ± 0.01	0.19 ± 0.058
2-360	0.05 ± 0.01	0.04 ± 0.01	0.06 ± 0.01	0.02 ± 0.00	0.01 ± 0.012

a. Not blank corrected.
b. Samples to a depth of 5 cm.
c. Concentrations are for the fraction of soil measuring less than 2 mm diameter.
d. Error term represents two standard deviations.

3.6 Ecological Studies

Carol M. Anderson

Ecological studies are performed to assess the short- and long-term implications of impacts to ecological resources that have occurred, are occurring, or may have occurred at the Rocky Flats Plant as a result of past operations. Ecological studies also are performed to ensure compliance with all applicable biological regulations. A detailed description of current and future ecological studies is provided in the following pages.

OVERVIEW

Ecological studies are an ongoing part of RFP routine operations. These studies focus on the presence, abundance, and spatial distribution of onsite plant and animal life (biota) and are fundamental in identifying adverse or positive impacts of RFP activities relative to NEPA and other state and federal regulations and guidelines. Specialized studies, including floodplain identification and radioecological studies, assist in investigating perturbations to the unique ecological aspects of the RFP.

The last comprehensive study of the environment at the RFP was conducted for the *Environmental Impact Statement, Rocky Flats Plant Site* (DOE80). Much of the information contained in that document was compiled before September 1977. As noted in the *Draft Environmental Analysis Report* (EG90a), more recent information is available on land use, wetlands, and other environmental elements. Current information on specific natural resources at RFP results from studies including *Wetland Assessment, Rocky Flats Site* (EG90b), and *Threatened and Endangered Species Evaluation, Rocky Flats Plantsite* (EG91e). The scope of the current ecological studies program has been determined by public demand for current information on RFP impacts and increased emphasis on requirements for NEPA pursuant to 10 CFR Part 1021. In addition, ecological risk assessment determinations are required by federal statutes, such as CERCLA and RCRA.

ECOLOGICAL MONITORING

To meet a growing priority for comprehensive, long-term ecological information concerning the plantsite, design and implementation of formalized ecological monitoring, the Ecological Monitoring Program (EcMP) was initiated in 1992. Primary goals of the EcMP are to (1) thoroughly assess trends in terrestrial and aquatic media, (2) demonstrate compliance with applicable federal, state, and local environmental regulations, (3) confirm adherence to ecological aspects of DOE environmental protection policies, (4) support risk-based, cost-effective environmental management decisions, and (5) monitor ecological resources both before and after remedial activities have been implemented.

RESOURCE PROTECTION

The Resource Protection Program (RPP) will conduct biological surveys and assessments to ensure compliance with environmental regulations (Endangered Species Act, Fish and Wildlife Coordination Act, Migratory Bird Treaty Act, Bald Eagle Protection Act, State of Colorado Wildlife Statute, Title 33, Article II, Endangered Wildlife, and Article III, Threatened Wildlife) for OUs and sitewide projects (DOE91a, DOE91b, DOE91c, DOE91d).

Two surveys were conducted in August 1992 related to the Endangered Species Act. Surveys were conducted for the Diluvium Ladies'-Tresses, a wild orchid listed as a federal threatened species, and for the Preble's Meadow Jumping Mouse, a Category 2 species. No Ladies'-Tresses were found during the survey. Preble's Meadow Jumping Mice were found in three areas of the buffer zone near Walnut Creek, Woman Creek, and Rock Creek.

ECOLOGICAL STUDIES

The following ecological studies were underway in 1992.

- Baseline Studies - inventories of aquatic and terrestrial wildlife and vegetation to establish OU baseline ecological conditions.
- Radioecological Investigations - studies of deer, small mammals, soils, and vegetation to evaluate various population parameters and radionuclide uptake in these populations, and to establish remediation standards.
- Environmental Evaluations - investigations that include ecological risk assessments to evaluate actual or potential effects that RFP environmental contaminants may have on plants and animals associated with the site.

Baseline Studies

Baseline studies serve as benchmarks against which future data may be compared to identify trends in the prominence of wildlife and vegetation resources at RFP. Information gathered on the presence, abundance, and distribution of aquatic and terrestrial vegetation and wildlife is used to measure the impacts of various intrusive activities on these natural resources and to

comply with the NEPA *Code of Federal Regulations*, 40 CFR Parts 1500-1508, 10 CFR Part 1021, and DOE Order 5440.1E, "National Environmental Policy Act Compliance Program." Baseline studies began in November 1990 and concluded in early 1992. The final baseline wildlife/vegetation survey report, which contains all the data gathered during the course of these investigations, was issued in September 1992 and covers three major investigative categories: aquatics, terrestrial vegetation, and terrestrial wildlife. Highlights of the report are provided below.

Aquatics. Two hundred thirty-six plant species and nine species of fish were documented in the Woman Creek, Walnut Creek, and/or Rock Creek drainages.

Terrestrial Vegetation. Baseline studies documented and/or confirmed the presence of 532 species of plants at RFP (DOE92). This is an increase of 248 species over the previously reported vegetation inventory (DOE80).

Terrestrial Wildlife. Six species of amphibians and eight species of reptiles were recorded. A total of 144 bird species were reported (DOE92c), a significant increase over the 38 species previously reported (DOE80). Thirty-three avian species were confirmed to nest at the RFP and an additional 22 were characterized as possible breeding species. Thirty-one species of mammals were documented including an uncommon finding of a water shrew (*Sorex palustris*) at a lower elevation than previously recorded in Colorado.

Radioecological Investigations

Deer. Deer ecology investigations assess the habitat use, population size, and radionuclide uptake by mule and white tail deer populations at RFP. In addition to supporting sitewide population and area use requirements, these investigations are needed to evaluate and develop strategies for reducing impacts of plant operations from remedial actions and alternative uses of the buffer zone. Investigations began in 1989 and were discontinued in August 1992 because the data consistently showed negligible uptake of radionuclides by the RFP deer population.

Study results suggest that deer use the Solid Waste Management Unit (SWMU) areas at RFP, but do not assimilate significant amounts of plutonium, uranium, or americium (CSU92c).

Small Mammals, Vegetation, and Soil. Radioecological investigations of small animals, vegetation, and soil are designed to (1) assess standards for remediation of plutonium and americium contamination in soils east of the 903 Pad, (2) evaluate the current distribution of plutonium, americium, and other radionuclides in the terrestrial environment near the 903 Pad, and (3) compare the present distribution of plutonium with that measured in the mid-1970s. A description and characterization of radionuclides in the biota is needed to support sitewide project activities, IAG actions, and future decisions concerning environmental remediation under RCRA and CERCLA.

Preliminary results indicate that mean plutonium concentrations in the vegetation have decreased from 1,056 Becquerels per kilogram (Bq/kg) reported for the 1972-1974 period (LI76) to 164 Bq/kg in 1989 (CSU92b), amounting to a decrease of approximately 84 percent. Likewise, plutonium accumulations in the soil showed a general decline from the 1972-1974 period (LI76) to 1989 (CSU92b). Plutonium in the soil and vegetation of the primary study area was estimated to be 463 kiloBecquerels per square meter (kBq/m^2) in 1989 (CSU92b), approximately 20 percent of the 1972-1974 estimates (LI76). No significant difference between small mammal tissue samples analyzed 18 years ago and samples collected for this study was found (CSU92a). This reconfirms findings in the earlier studies that small mammals are not assimilating ecologically significant quantities of plutonium or americium; therefore, the small mammal studies have been discontinued. The vegetation and soil studies were discontinued at the end of FY92, and a comprehensive report containing all of the data and conclusions generated by these studies will be prepared by April 1, 1993.

Environmental Evaluations

An Environmental Evaluation (EE) is an assessment of actual or potential adverse effects of contamination at hazardous waste sites on plants and animals other than people or domesticated species. Ecological assessments of hazardous waste sites are an essential element in determining overall risk and protecting public health, welfare, and the environment, and are required to be performed under CERCLA.

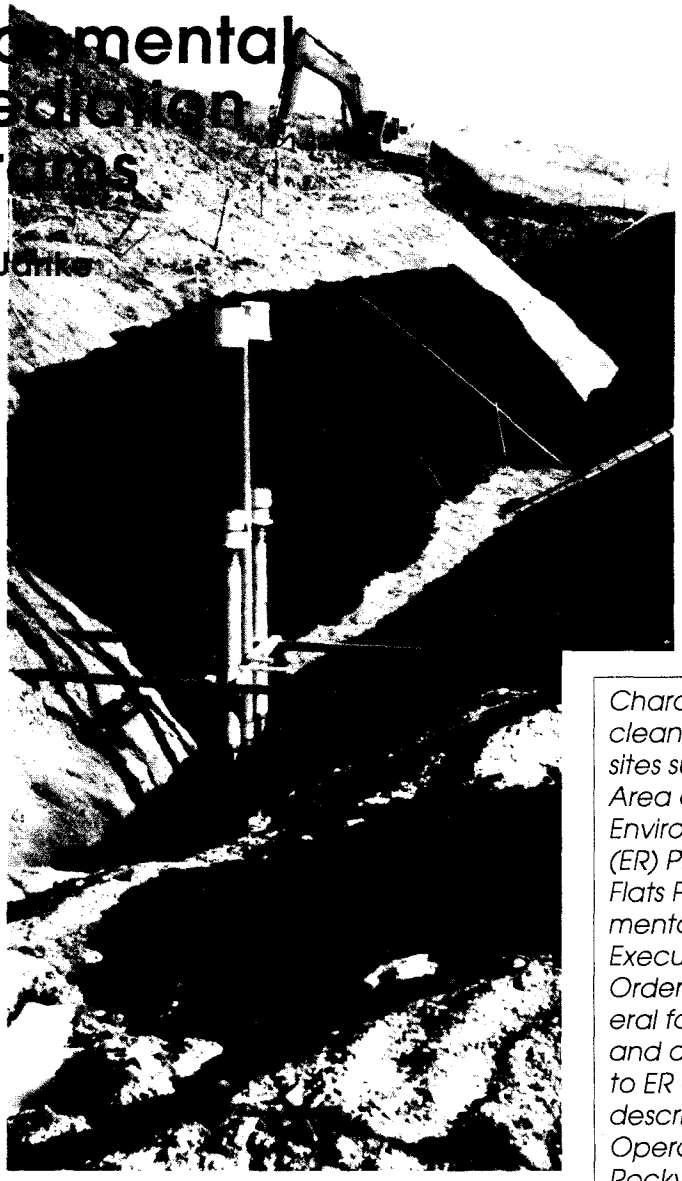
Hazardous waste site EEs are intended to provide decision makers with information on risks to the natural environment that are associated with contaminants or with actions designed to remediate the site. The EE provides information to determine whether the ecosystem has been, or has the potential to be, damaged by hazardous substances and/or wastes released into IHSSs defined under the IAG. Under the IAG, the IHSSs and SWMUs have been grouped into 16 OUs (see Section 4, Environmental Remediation Programs). Information from the EEs assists in determining the form, feasibility, and extent of remediation necessary for the RFP in accordance with applicable state and federal regulations. The development of a standardized ecological approach and development of individual OU-specific EE work plans provide focused investigations of potential adverse effects of contamination on the biota of the RFP and the surrounding area. Results of the studies are presented in the EE reports submitted as a chapter of the RCRA/CERCLA Facility Investigations/Remedial Investigations (RFI/RI) Report for each OU.

Field sampling has been completed for OUs 1, 2, 5, 6, and 7. Field sampling is occurring in OU 3 and will begin in OU 4 in April 1993.

The draft version of the OU 1 RFI/RI report was submitted in October 1992, and is presently undergoing review by the DOE, EPA, and CDH.

4. Environmental Remediation Programs

Jeffrey E. Jarka



Characterization and cleanup of inactive waste sites such as the 881 Hillside Area are the focus of Environmental Remediation (ER) Programs at the Rocky Flats Plant. Various environmental laws, regulations, Executive Orders, DOE Orders, and state and federal facility agreements and consent orders apply to ER activities. This section describes the various Operable Units identified at Rocky Flats and the status of remediation activities in those areas.

OVERVIEW

The ER Program at RFP began in 1986 and has continued to grow in recent years with the FY92 program reaching $69,183,000. Additional growth is anticipated in the future as the plant continues with an aggressive ER Program, initially established to comply with regulations for characterization and cleanup of inactive waste sites at RFP. The program specifically includes inactive site identification and characterization, remedial design and cleanup action, and post-closure activities of inactive radioactive, hazardous, and mixed waste sites. The primary objective of the program is to bring all known waste sites at RFP into compliance with applicable federal, state, and local environmental laws and regulations, and at the same time ensure that risks to human health and the environment are reduced to prescribed levels or eliminated entirely.

Various environmental laws, regulations, Executive Orders, DOE Orders, and state and federal facility agreements and consent orders apply to ER Programs. The DOE negotiated several agreements with the EPA and CDH that address compliance with environmental regulations, scope of work, and timetables that require DOE compliance. The legal framework that establishes the scope and schedule for projects in the ER Program is the IAG, which was signed by the DOE, the EPA, and CDH on January 22, 1991. EPA's Land Disposal Restrictions (LDRs) are addressed by a FFCA, while the AIP between the DOE and the State of Colorado imposes additional monitoring requirements and requires acceleration of cleanup activities where contamination presents a potential threat to human health or the environment.

The IAG and its attachments address details on specific response requirements that must be met during the CERCLA and the RCRA processes used to assess and remediate identified IHSSs on or adjacent to RFP. These 178 IHSSs have been grouped into 16 OUs based on cleanup priorities, waste type, and geographic location (Table 4-1). The IAG Statement of Work (SOW) provides details on the activities that must occur and the sequence of those activities to satisfy the requirements of the IAG. During 1992, 27 IAG milestones were met on the original schedule or on extension dates approved by the regulatory agencies. Since the program's inception, 89 IAG milestones have been met: 68 on the original IAG schedule date and 21 on

agency-approved extension dates. Because of added requirements and increased scope required to complete ER work, and because of funding limitations and other issues, the DOE has approached the regulatory agencies to amend the schedules and milestones in the IAG. These negotiations are currently ongoing.

The increasing importance of and management attention to ER activities were reflected in a major reorganization that occurred in late 1992 in the former EG&G Environmental Restoration and Waste Management (ERWM) organization. ER was established as a separate organization with its own associate general manager. The structure of ER is continuing to evolve into an organization designed to address the significant technical, programmatic, and regulatory issues facing the OUs and other ER projects.

The Solar Ponds Pondcrete Project was also reorganized in 1992 to strengthen its project management and coordination of technical activities. To date, the Pondcrete Project has shipped more than 9,000 blocks of pondcrete to the Nevada Test Site (NTS), completed construction of three 18,000-gallon-per-day evaporators, completed construction of three 500,000-gallon surge tanks for collection of interceptor trench water, and emptied Pond 207A.

During the second half of 1992, several enhancements were implemented to correct identified deficiencies in the ER sample management process and in the Rocky Flats Environmental Database System (RFEDS). Sample management staff was enhanced, and the pool of qualified laboratories for radionuclide analysis increased by four. These efforts resulted in an increase in laboratory capacity, a decrease in sample backlog, and in the case of one laboratory, a decrease in laboratory turnaround time from 120-180 days to 61-75 days.

The following sections describe the 16 OUs and address the major activities conducted during 1992. Individual maps of all OUs (Figures 4-1 through 4-16) are located at the end of this section.

Table 4-1

Organization of Individual Hazardous Substance Sites (IHSSs) into Operable Units (OUs)

Operable Unit #	Individual Hazardous Substance Sites
1	102, 103, 104, 105.1, 105.2, 106, 107, 119.1, 119.2, 130, 145
2	108, 109, 110, 111.1, 111.2, 111.3, 111.4, 111.5, 111.6, 111.7, 111.8, 112, 113,140, 153, 154, 155, 183, 216.2, 216.3
3	199, 200, 201, 202
4	101
5	115, 133.1, 133.2, 133.3, 133.4, 133.5, 133.6, 142.10, 142.11, 209
6	141, 142.1, 142.2, 142.3, 142.4, 142.5, 142.6, 142.7, 142.8, 142.9, 142.12, 143, 156.2, 165, 166.1, 166.2, 166.3, 167.1, 167.2, 167.3, 216.1
7	114, 203
8	118.1, 118.2, 123.1, 135, 137, 138, 139.1, 139.2, 144, 150.1, 150.2, 150.3, 150.4, 150.6, 150.7, 150.8, 151, 163.1, 163.2, 172, 173, 184, 188
9	121, 122, 123.2, 124.1, 124.2, 124.3, 125, 126, 127, 132, 146, 147.1, 149, 159, 215
10	129, 170, 174, 175, 176, 177, 181, 182, 205, 206, 207, 208, 210, 213, 214
11	168
12	116.1, 116.2, 120.1, 120.2, 136.1, 136.2, 147.2, 157.2, 187, 189
13	117.1, 117.2, 117.3, 128, 134, 148, 152, 157.1, 158, 169, 171, 186, 190, 191, 197
14	131, 156.1, 160, 161, 162, 164.1, 164.2, 164.3
15	178, 179, 180, 204, 211, 212, 217
16	185, 192, 193, 194, 195, 196, 197

OU 1 - 881 HILLSIDE ASSESSMENT/REMEDIATION

OU Description

The alluvial groundwater at the 881 Hillside Area, located north of Woman Creek in the southeast section of RFP, was contaminated in the 1950s, 1960s, and 1970s with solvents and some radionuclides. Naturally occurring uranium also is present in the area. The 881 Hillside Area is almost 2 miles from the eastern, outer edge of the plant's buffer zone at Indiana Street, and poses no immediate threat to public health because it is contained within the plant's boundaries. The various IHSSs that make up OU 1 are being investigated and treated as high-priority sites because of elevated concentrations of organic compounds in shallow

groundwater and the proximity of the contamination to a drainage system (Woman Creek) that leads to an off-site drinking water supply (Standley Lake). The selected Interim Remedial Action (IRA) at OU 1 involved the construction of an underground drainage system called a French drain to intercept and contain contaminated groundwater flowing from the OU 1 area. The contaminated water is treated at the Building 891 treatment facility, designed for this purpose, and released onsite into the South Interceptor Ditch. The Remedial Investigation (RI) and Feasibility Study (FS) to determine the final remedial actions are continuing in parallel with the interim activities. Depending upon future analyses, the IRAs may represent the final remedial action.

A major accomplishment in the 881 Hillside remediation effort occurred in 1992 when construction of the French drain and treatment facility was completed. Calibration and systems operation testing inside Building 891 were completed in March, followed by treatment of contaminated groundwater beginning in May. Building 891 houses an ultraviolet (UV) peroxide process to treat organics and an ion exchange system for removal of metals. Seeding, mulching, and revegetation of the French drain area was successfully initiated and completed during April and May.

During 1992, a total of 602,500 gallons of shallow groundwater was treated in the Building 891 treatment facility.

Before treatment operations began, several field activities were completed in 1992. Field work for a Phase III RI began in August 1991 and was completed in January 1992. This RI implemented the detailed work plan approved by EPA and CDH. In the OU 1 Phase III RI, 56 boreholes and 39 wells were drilled, and 23 of the wells were completed as monitoring wells. Forty-six water samples, 280 soil samples, and 85 sediment samples were collected and analyzed, and 46 geotechnical samples were tested. The 14-volume draft RI report, including the Baseline Risk Assessment, was completed and submitted to the regulatory agencies on October 28, 1992, the extended IAG milestone date. The French Drain Monitoring and Mitigation Plan, with added scope, was approved by the DOE in June 1992.

OU 2 - 903 PAD, MOUND, AND EAST TRENCHES ASSESSMENT/REMEDIATION

OU Description

Contamination at the 903 Pad Area is largely attributed to the storage in the 1950s and 1960s of waste drums containing cutting oils and carbon tetrachloride contaminated with plutonium. The drums were removed in 1967 and 1968; however, drums that had corroded allowed hazardous and radioactive material to leak onto the surrounding soil. Additional contamination may have resulted from wind dispersion during drum removal and soil movement activities when the area was covered with an asphalt pad in 1969 to provide containment. In the 1960s, similar barrels contaminated with uranium were stored at the Mound Area. Preliminary cleanup of the Mound Area was accomplished in 1970, and the barrels and material removed were packaged and shipped offsite as radioactive waste. The East Trenches Area was used for disposal of plutonium- and uranium-contaminated waste and sanitary sewage sludge from 1954 to 1968. Two areas adjacent to the trenches were used for spray irrigation of STP effluent, some of which may have had contaminants that were not removed by the treatment system.

A Phase I RI of OU 2 was initially completed in 1986. This was followed by an Interim Measures/Interim Remedial Action (IM/IRA) that provides for surface water in source areas of contamination to be collected, treated, and discharged to the surface water drainage. Operation of a field-scale treatability unit for the South Walnut Creek drainage began in May 1991. The effectiveness of the treatment process is being evaluated at three locations: the entrance to the treatment facility, several points within the facility, and the discharge points. After completion of the field-scale treatability tests, the unit is anticipated to remain in service until the final remedial action is operational.

The single IM/IRA originally planned for OU 2 was divided into two IRAs in FY90 as a result of public review of the plans and following agreement among DOE, EPA, and CDH. One phase will collect and treat water from the South Walnut Creek drainage; the other phase will do the same for the Woman Creek drainage.

The alluvial portion of a Phase II RI, which will provide data for the final remediation decision, was begun in September 1991 and completed in November 1992. A proposed schedule for the bedrock portion of the RI is currently under review by the regulatory agencies. In the alluvial portion of the RI, 48 boreholes were drilled, 111 wells were drilled and completed as monitoring wells, 5 surficial soil trenches and 20 surficial test pits were completed, and 135 water samples and 625 soil samples were collected and analyzed.

The OU 2 South Walnut Creek Surface Water IM/IRA Decision Document was approved by the EPA and CDH in May 1991. Phase I of this project, which began in May 1991, includes the collection, storage, and treatment of surface water for removal of organics using granular activated carbon (GAC). Phase II of this IRA, which added a radionuclides removal system, was completed in April 1992. By the end of 1992, the Phase I and Phase II systems successfully collected, treated, and discharged approximately 11 million gallons of surface water.

The concept for a subsurface vapor extraction IRA for OU 2 was approved by the EPA and CDH. The final Subsurface Interim Measures/Interim Remedial Action Plan/Environmental Assessment (IM/IRAP/EA) was submitted in August 1992. This proposed subsurface IM/IRAP/EA will be conducted on an area located north of Woman Creek that encompasses the 903 Pad, the Mound Area, and the East Trenches Area of OU 2. This interim action will identify and evaluate IRAs for removal of residual free-phase VOC contamination from three distinct subsurface environments at OU 2. Each of the proposed VOC-removal actions involve *in situ*, vacuum-enhanced vapor extraction technology. The IRAs are proposed for the collection of information that will aid in the selection and design of final remedial actions that address subsurface, residual free-phase VOC contamination at OU 2. The pilot test plan for the first stage of this project was delivered to the regulatory agencies on October 29, 1992, the IAG milestone date. The system will employ *in situ,* vacuum-enhanced vapor extraction to treat soils in the vadose zone in OU 2 IHSSs for volatile organics.

OU 3 - OFFSITE AREA ASSESSMENT

OU Description

OU 3 remedial activities are divided into two main categories. In the first category, the IAG directs activities according to CERCLA. This involves assessment of contamination in offsite IHSSs. The second category responds to a 1985 settlement agreement among DOE, former plant operators Rockwell International and the Dow Chemical Company, local governments, and private landowners. The 1985 Settlement Agreement requires remediation actions to reduce plutonium concentrations in areas adjacent to the eastern boundary of RFP. Remedial activities in response to the settlement agreement (deep disc plowing) began in 1985. The soil disturbed by remediation is being revegetated with limited success. The overall schedule for this activity is determined by the year-to-year success of the revegetation effort and requirements of the landowners.

The Historical Information and Preliminary Health Risk Assessment Report and Past Remedy Report for OU 3 were completed and approved by the DOE and the regulatory agencies in FY91. The Past Remedy Report details the history of the remedy ordered by the United States District Court pursuant to the Settlement Agreement, the implementation of the remedy, and the effectiveness of the remedy. The Final Historical Information Summary and Preliminary Health Risk Assessment Report provided known data describing contamination within three offsite reservoirs: Great Western Reservoir, Standley Lake Reservoir, and Mower Reservoir.

Draft and Final Offsite Area RFI/RI Work Plans were delivered to EPA and CDH in 1991. The revised final RI Work Plan was approved by the regulatory agencies on March 17, 1992. RI field work began in May 1992, although some field work activities were delayed by the inability to access privately owned offsite lands.

ER initiated offsite reservoir sampling and soil trenches at the three nearby reservoirs. Sediment sampling of Great Western Reservoir occurred in May, followed by shoreline sampling of Standley Lake in June. Environmental Evaluation (EE) work was completed October 23, 1992. To date, 250 of 290 planned soil samples, all 230 sediment samples, 110 of 124 water samples, and all 180 biota samples were collected and sent to analytical laboratories for analysis.

OU 4 - SOLAR PONDS ASSESSMENT

OU Description

OU 4 is comprised of five solar evaporation ponds: 207A, 207B series (north, center, south), and 207C. Beginning in the late 1950s and continuing until 1986, the ponds were used to store and evaporate low-level radioactive process water containing high concentrations of nitrates and treated acidic wastes. The sludge and sediments that resulted from the process were periodically removed and disposed at the NTS.

As technology improved through the 1960s and 1970s, the ponds were relined with various upgraded materials; however, leakage from the ponds into the soil and groundwater was detected. Interceptor trenches were installed in 1971 to collect and recycle groundwater contaminated by the ponds and to prevent natural seepage and pond leakage from entering North Walnut Creek. In 1981, these trenches were replaced by the current and larger interceptor trench system, which recycles approximately 4 million gallons of groundwater a year back into the solar evaporation ponds. Presently, only the 207B north solar evaporation pond receives contaminated groundwater collected by the interceptor system.

The ponds are RCRA interim status regulated units that are currently under closure. To proceed with remedial measures and characterize the level of contamination at the site, approximately 8 million gallons of excess liquid in the ponds must be removed. The removal of this liquid and the redirection and treatment of the groundwater by the interceptor trench system were the focus of IRA activities that were initiated in 1992.

DOE's proposed cleanup action involves an initial partial closure of the ponds to eliminate the flow of harmful contaminants into groundwater and soil. The method of action calls for evaporation of the pond water and sludge removal. Sludge removed from the ponds and solidified with Portland cement (referred to as "pondcrete") will eventually be transported to the NTS.

The ponds will be dewatered by natural evaporation, enhanced natural evaporation, and forced evaporation. OU 4 received significantly increased attention during 1992, illustrated by the complete reorganization and expansion of the Pondcrete Project Office. The new

organization is now staffed with a sufficient number of dedicated personnel to manage all the critical aspects of the project.

The Final RFI/RI Work Plan for OU 4, submitted to the regulatory agencies on November 26, 1991, the IAG milestone date, was granted conditional approval in May 1992, allowing field activities to begin in the Protected Area (PA). The RFI/RI subcontract to implement the work plan was awarded, mobilization began in November 1992, and field work began in December.

Ground Penetrating Radar and Radiation Surveys were completed in Pond 207A; two 12- to 15-foot boreholes were completed inside the PA, and soil samples were collected and forwarded to analytical laboratories; FIDLER (Field Instrument for the Detection of Low-Energy Radiation) surveys in the buffer zone neared completion; and borehole locations in the buffer zone were marked and cleared by EG&G Construction Management.

Other significant activities accomplished include continued repackaging of deteriorated pondcrete and saltcrete blocks; waste characterization for pondsludge, pondcrete, and saltcrete; formulation of the RFP Waste Certification Plan, which is in final review; completion of a request for change to interim status to incorporate the processing of pondsludge into the RFP RCRA operating permit; construction completion of three 18,000-gallon-per-day evaporators in Building 910; and completion of three 500,000-gallon modular tanks to function as surge tanks in collecting Interceptor Trench water at a rate of 4 million gallons per year.

Pond 207A was emptied during 1992, and the IM/IRA for the construction and operation of the Building 910 evaporator was approved. In addition, the waste analysis plan for Pond 207C and clarifier was completed and submitted to NTS for review, a Health and Safety Plan was completed, and Safety Analysis Reports (SARs) for the pondsludge processing, Building 910, and mixed waste storage on the 750 and 904 pads were completed and started DOE review.

OU 5 - WOMAN CREEK ASSESSMENT

OU Description

OU 5 consists of several IHSSs within the Woman Creek drainage, including Detention Ponds C-1 and C-2. Two additional surface disturbances have been identified, one located south of IHSSs 133.1 - 133.4 and one located west of IHSS 209. These last two sites were included in the OU 5 Work Plan.

A Final Phase I RFI/RI Work Plan submitted to the EPA and CDH in December 1991 received conditional approval in February 1992, allowing field work to begin. The RFI/RI investigates and defines the site physical characteristics, defines the sources of contamination, and describes the nature and extent of contamination. In addition to the RFI/RI, two Technical Memoranda further defining requirements of the work plan were approved by the regulatory agencies and implemented. The Final Health and Safety Plan was also completed. Three of 14 monitoring wells were completed, and 12 of the planned 48 surface water and pond water samples were collected. Eight borings were completed, and all of the 13 stream and pond sediment samples were taken and forwarded to laboratories for analysis. The scheduled magnetic and electromagnetic geophysical survey of IHSS 133 was completed, and a High Purity Germanium (HPGe) radiation survey and EE field work were implemented and continued during 1992.

OU 6 - WALNUT CREEK ASSESSMENT

OU Description

OU 6 consists of IHSSs within the Walnut Creek drainage. Thirteen additional groundwater monitoring wells will be installed throughout OU 6 to monitor the alluvial aquifer. Five bedrock groundwater monitoring wells will be installed in the vicinity of North Walnut Creek to characterize the bedrock aquifer, and nine additional bedrock groundwater monitoring wells may be installed in the vicinity of the A-series ponds.

Sediment samples are proposed to be taken along each stream segment on North and South Walnut Creeks where existing data are insufficient to characterize the sediments adequately. Elsewhere within the OU 6

drainage there is sufficient information about the sediments leading to a reduction in the number of sampling locations. Surface-soil sampling was modified for the Triangle Area (IHSS 165) and the Old Outfall Area (IHSS 143) to enable sampling of the original surface area by borings through the overlying fill.

During 1992, revisions to the Final Phase I RFI/RI Work Plans were completed and conditional approval was received from the regulatory agencies in February. Field work began in September with surface soil sampling completed in October for IHSSs 167.1 and 167.3. The soil gas survey of IHSS 165 also was completed in October. Seven monitoring wells were completed in 1992, while all 52 surface water samples and 50 pond sediment samples were taken. Forty-eight of 105 borings also were completed and sampled. All geophysical surveys were completed.

Field activities implementing the OU 6 Work Plan will continue in 1993. The Draft Phase I RFI/RI Report is scheduled to be submitted to EPA on August 4, 1993.

OU 7 - PRESENT LANDFILL

OU Description

The Present Landfill, OU 7, is located north of the plant complex on the western edge of an unnamed tributary of North Walnut Creek. OU 7 is comprised of two IHSSs. IHSS 114 includes landfill waste and leachate at the Present Landfill, soils beneath the landfill potentially contaminated with leachate, and sediments and water in the East Landfill Pond. IHSS 203 contains potentially contaminated soils at the Inactive Hazardous Waste Storage Area. The Present Landfill began operations in August 1968 and was originally constructed to provide for disposal of RFP's nonradioactive and nonhazardous wastes. In September 1973, tritium was detected in leachate from the landfill. Extensive investigations conducted in the mid-1980s on the waste being disposed at the landfill subsequently led to the identification of hazardous wastes and hazardous constituents. Although currently operating as a nonhazardous sanitary landfill, the facility is considered to be an inactive hazardous waste disposal unit undergoing RCRA closure.

The Draft and Final RFI/RI Work Plans for OU 7 were completed on the IAG schedule dates, and conditional approval was received from the regulatory agencies in

August 1992. The Draft Human Health Risk Assessment (HHRA) and two Technical Memoranda (Exposure Assessment and Modeling) were completed in December 1992. Mobilization for the field work began in September, with field work beginning in October 1992. EE surveys were completed in November, soil gas and surficial soil sampling on IHSS 203 was completed, and cone penetrometer drilling in IHSS 114 began in December. Through December 20, 250 soil samples were collected, and 50 soil gas samples were collected and analyzed. Surficial soil sampling is continuing.

The next OU 7 IAG milestone scheduled for delivery to the EPA and CDH is the Draft Phase I RFI/RI Report, due on October 12, 1993.

OU 8 - 700 AREA ASSESSMENT

OU Description

OU 8 consists of IHSSs inside and around RFP production areas in the 700 Area. Contamination sources within the various IHSSs include above-ground and underground tanks, equipment washing areas, and releases inside buildings that potentially affected areas outside of buildings. Contaminants from these sources may have been introduced into the environment through spills on the ground surface, underground leakage and infiltration, and in some cases, through precipitation runoff. The chemical composition of the contaminants varies widely among the IHSSs, ranging from low-level radioactive mixed wastes to nonradioactive organic and inorganic compounds.

During April 1992, 14 IHSSs were deleted from OU 8 and added to OU 9 as part of an IHSS realignment pursuant to Part 32 of the IAG. The IHSS changes were recommended by the DOE in the now-approved OU 9 Phase I RFI/RI Work Plan and approved by the CDH and EPA in April 1992.

The Draft RFI/RI Work Plan was submitted on May 1 and was revised in response to CDH-identified deficiencies. The revised Draft Work Plan was submitted on June 22, and the final was submitted on December 1, 1992. The identified deficiencies highlighted procurement concerns, which helped prompt a change in the procurement system and subsequent reorganization of

ER as a separate organization with its own associate general manager.

Another significant accomplishment related to OU 8 and several other OUs was the development of an Optimal Interim Remedial Action Plan (O/IRAP), which will combine part of the field work for OUs 8, 9, 10, 12, 13, and 14. The plan provides an integrated approach to RIs, allowing the integration of common work in different OUs under one contract to provide for effective and efficient use of available resources and monetary savings.

OU 9 - ORIGINAL PROCESS WASTE LINES ASSESSMENT

The Original Process Waste Lines (OPWL), OU 9, consists of a system of 57 designated pipe sections extending between 73 tanks and 24 buildings connected by 35,000 feet of buried pipeline. The pipeline transferred process wastes from points of origin to onsite treatment facilities. The system was originally placed into operation in 1952, with additions and modifications occurring through 1975. The original system was replaced during the 1975 to 1983 period by the new process waste system. Some tanks and lines from the original system were incorporated into the new process waste system or into the fire water deluge collection system.

The original system is known to have transported or stored various aqueous process wastes containing low-level radioactive materials, nitrates, caustics, and acids. Small quantities of other liquids also were introduced into the system, including pickling liquor from foundry operations, medical decontamination fluids, miscellaneous laboratory liquids from Building 123, and laundry effluent from Buildings 730 and 778.

The revised Phase I RFI/RI Work Plan submitted February 25, 1992, includes inspection and sampling of the original system's tanks and pipelines that are accessible, and soil sampling to determine the extent of contamination in the vadose zone. The soil sampling will be performed by installing test pits and borings where known or suspected releases occurred, near pipe joints and valves, at approximately 200-foot intervals along the pipeline route, and by installing borings around outdoor tanks. Soil characterization studies will determine the need for soil removal and/or treatment. The results of the RFI/RI will determine the need for interim and/or final remediation activities.

OU 9 experienced a significant scope increase in April 1992 when 20 IHSSs were added to the work plan from other OUs. Fourteen IHSSs were added from OU 8, three from OU 10, and one each from OUs 12, 13, and 15. The Health and Safety Plan, Implementation Plan, and Field Sampling Plan were developed during 1992. Work will continue on OU 9 during 1993. The next IAG milestone, the Draft RFI/RI Report, is scheduled for submittal in April 1994.

OU 10 - OTHER OUTSIDE CLOSURES ASSESSMENT

OU 10 is comprised of IHSSs scattered throughout the plant that consist of various hazardous waste units. Five of the IHSSs are located in the PA, two are in the buffer zone near the Present Landfill, and the remaining are located near various buildings throughout the plant. The types of wastes identified at these sites range from pondcrete/saltcrete storage and drum storage, to a utilization yard where waste spills occurred.

The Draft Final RFI/RI Work Plan was submitted to the regulatory agencies on May 1, 1992, and conditional approval was received in September. The primary components of the Work Plan include a Field Sampling Plan (FSP), Baseline Risk Assessment Plan (BRAP), and an EE Work Plan.

OU 11 - WEST SPRAY FIELD ASSESSMENT

The West Spray Field is located within the RFP property boundary immediately west of the main facilities area. The West Spray Field was in operation from April 1982 to October 1985. During operation, excess liquids from solar evaporation ponds 207B north and center (containing contaminated groundwater in the vicinity of the ponds and treated sanitary sewage effluent) were pumped periodically to the West Spray Field for spray application. The spray field boundary covers an area of approximately 105 acres, of which approximately 38 acres received direct application of hazardous waste.

The Final RFI/RI Work Plan was submitted to the regulatory agencies on January 2, 1992, and conditional approval was received on May 26, 1992. The RFI/RI process will entail field studies to determine the presence and levels of hazardous constituents in soil and groundwater.

OU 12 THROUGH OU 16

The following OUs consist of lower priority areas for which various remedial activities will continue during 1993.

OU 12 - 400/800 Area. Contamination in the OU 12 area originates from cooling tower ponds, chemicals from fiberglass operations, leaks, and multiple solvent spills that may have contaminated the soils with VOCs and other organics, metals, and acids. The Draft Phase I RFI/RI Work Plan was submitted on May 8, 1992, revised in response to agency comments, and resubmitted on December 18, 1992.

OU 13 - 100 Area. OU 13 comprises chemical storage areas, an underground tank, waste destruction areas, a valve vault, and locations where minor leaks or spills occurred. The soil has received VOCs and other organics, depleted uranium, acids, caustics, and metals from these IHSSs. The Draft RFI/RI Work Plan was submitted on May 15, 1992, and the final was submitted on October 12, 1992. The Field Sampling Plan was revised to provide more comprehensive surficial soils components, and the CDH requested an increase of surficial soil sampling from 54 to 130 samples.

OU 14 - Radioactive Sites. OU 14 consists of storage areas for radioactive soils removed from near the radiological operations buildings. A Draft RFI/RI Work Plan was submitted on June 26, 1992, and a final on October 19, 1992. EPA approval is pending.

OU 15 - Inside Building Closures. OU 15 includes structures within buildings where hazardous materials were stored or processed. Types of waste include oils, coolants, and solvents containing chlorinated hydrocarbons, and waste paints and waste metals contaminated with solvents. Hazardous constituents include chlorinated solvents, beryllium, and uranium. The draft work plan was submitted on June 1, 1992, and the final work plan was submitted on October 26, 1992. Conditional agency approval, with comments, was received on December 11, 1992.

OU 16 - Low Priority Sites. OU 16 covers miscellaneous leak and waste treatment sites that are considered the least likely to cause health or environmental problems. The soils at these sites may have been contaminated by organics, solvents, and nickel carbonyl. A draft No Further Action Justification (NFAJ) document

was submitted on March 5, 1992, and a final on July 30, 1992. The document provides technical justification for no additional investigation or remediation at seven individual IHSSs. Agency review is continuing.

SITEWIDE ACTIVITIES

Sitewide activities include several tasks that encompass a wide variety of plans, procedures, reports, studies, and other activities required by the IAG and that apply to RFP environmental restoration activities in general.

Sitewide Treatability Studies

The Sitewide Treatability Studies Annual Report, an IAG milestone scheduled for delivery to EPA and CDH on March 8, 1993, continued development during 1992. The annual report includes a summary of the status of each of the sitewide projects, a literature review of new and emerging technologies, and a summary of other relevant environmental projects at RFP.

The RFP Environmental Science & Engineering (ESE) group is working with Technology Development and the Los Alamos Technology Office (LATO) to develop a Technical Task Plan (TTP) to study Plutonium Solubilization for Remediation Applications. The purpose of this TTP is to develop an understanding of the soil chemistry at RFP and the relationship to how plutonium is found in the RFP soils. The TTP will be submitted to LATO.

The following Sitewide Treatability Studies activities began or were in process during 1992: Physical Separation, Chemical Separation, Potassium Ferrate Precipitation, Adsorption, Colloid filter polishing method, Plasma Melter, Solar Detoxification, Annual Report preparation, pondcrete evaluation report, bioremediation literature search and technical proposal preparation, colloid studies, flow pump testing, seep study, and the acquisition of an Inductively Coupled Plasma - Mass Spectrometer (ICP-MS).

Environmental Sample Management

Several enhancements were implemented in 1992 to correct identified deficiencies in the ER sample management process and in the RFEDS. Sample management staff was increased, and the pool of qualified laboratories for radionuclides analysis was increased by four. These efforts resulted in an increase in laboratory

capacity and a decrease in sample backlog. Cost management of the large ER sample analysis budget was addressed. The ER staff is working with EG&G Procurement, Accounting, and Central Planning to develop a customized system for handling analysis accruals and invoices so that accurate, up-to-date charges are assessed against ER projects for sample analysis.

Community Relations Plan

The Community Relations Plan (CRP) was approved by EPA and CDH and issued in December 1991. All requirements associated with the CRP were completed on schedule during 1992. Major activities completed during 1992 are provided below.

- Monthly coordination meetings continued to be held with the EPA and CDH.
- Six Environmental Restoration Update newsletters were issued to the public.
- Four quarterly public information meetings, as required by the IAG, were conducted in 1992.
- A Technical Review Group (TRG), composed of representatives from local municipalities and local environmental groups, met monthly to provide public input on draft work plans and other documents.
- All required documents were placed in the Rocky Flats Public Reading Room and other public repositories.
- As required by the CRP, numerous tours, presentations, and briefings were conducted during the year.

Groundwater Monitoring

A comprehensive groundwater monitoring program that began at RFP in 1986 was expanded significantly in recent years. Seventy new wells were added in 1986 to the existing 30 wells; an additional 67 wells were added in 1987; and 160 wells were added in 1989, bringing the total to 260 wells after some older wells were abandoned. In 1991, approximately 150 new wells were added, and in 1992, approximately 30 new wells from the OUs 1 and 2 drilling programs were added, bringing the total to 430 wells. All wells are sampled quarterly. In December 1992, EG&G and DOE presented a proposal to EPA and CDH for a three-phase well evaluation

program. This proposal would allow the discontinuance of routine monitoring at certain wells that are not providing new data. This would help conserve funds for new wells entering the program through OU characterization activities.

Administrative Record

CERCLA and the IAG require that an Administrative Record (AR) be established for the ER Program. The AR is required to document the basis for response selection and adequacy of response selection for the cleanup of IHSSs as well as to serve as a vehicle for public participation in the selection of the response action. Preliminary scheduling and organization of the AR began in 1990. The first AR index was compiled in December 1990, and a total of seven indexes were delivered to the regulatory agencies since 1990. In November 1991, microfiche reader/printers were purchased and placed in the four public repositories for public use in viewing the AR microfiche; the first set of microfiche was installed in the public repositories in February 1992. A total of 1,907 documents are currently included in the AR (90,634 pages processed). The number of documents processed for inclusion in the AR during FY92 totaled 1,567 (75,324 pages processed). The AR Screening and Processing Procedure was completed and approved on December 4, 1992.

Historical Release Report

The Historical Release Report (an IAG milestone) was prepared, and the final draft was delivered to the regulatory agencies on June 3, 1992. The Historical Release Report documents all contaminant spills and releases at RFP since the beginning of plant operations.

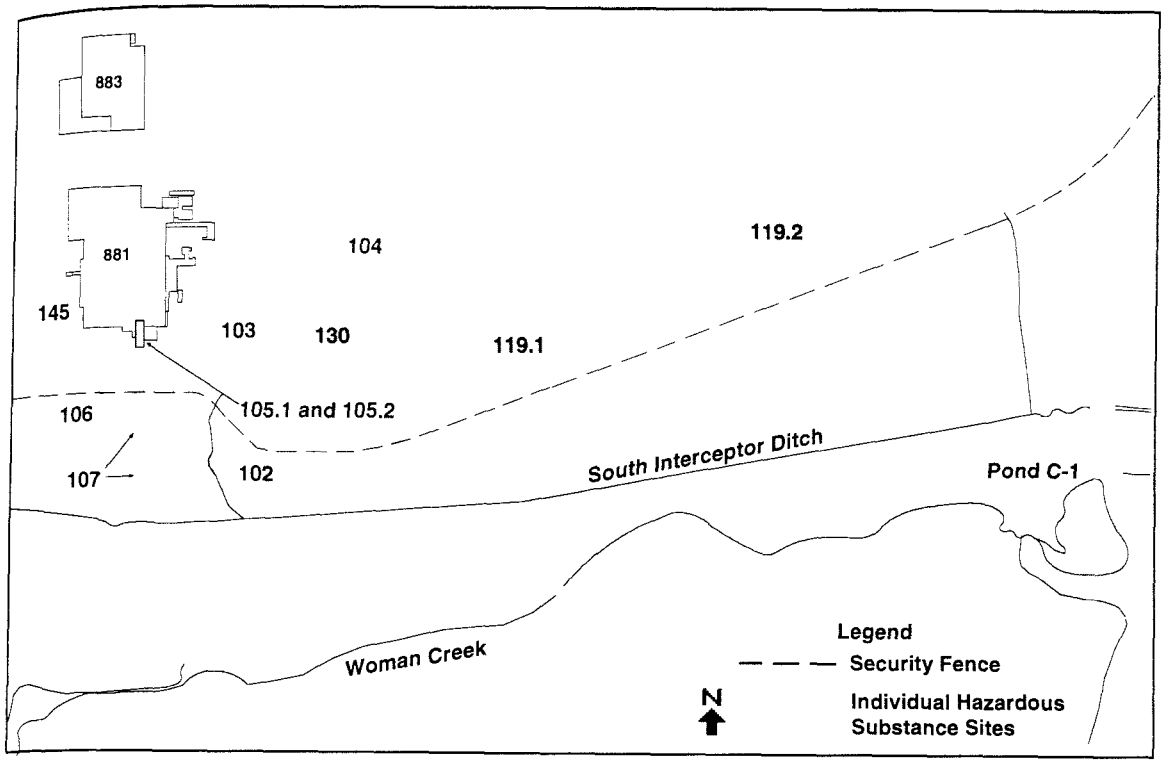


Figure 4-1. Operable Unit 1 - 881 Hillside

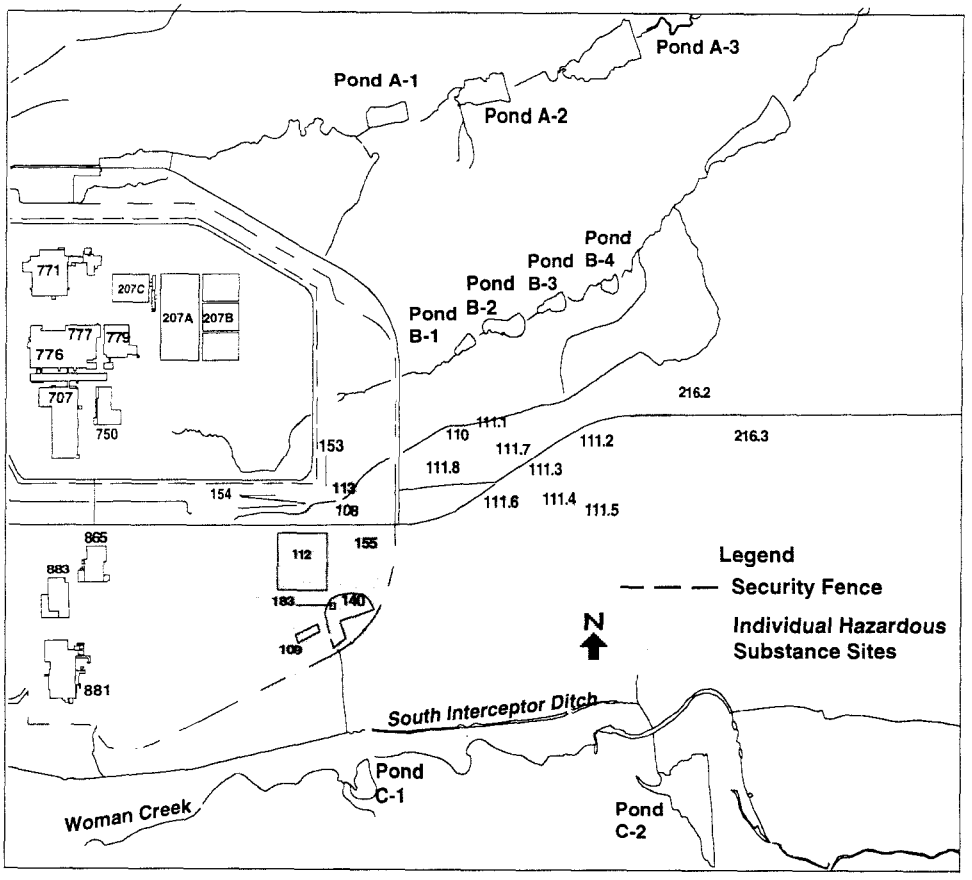


Figure 4-2. Operable Unit 2 - 903 Pad, Mound, East Trenches

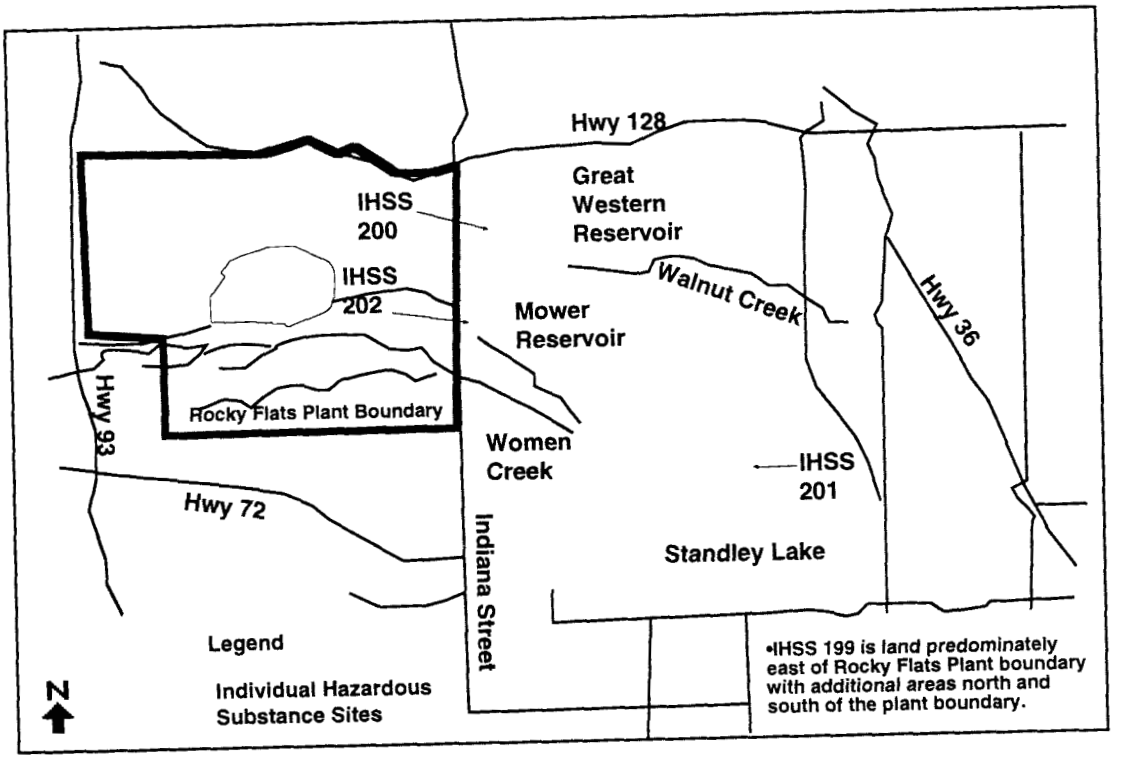


Figure 4-3. Operable Unit 3 - Offsite Releases

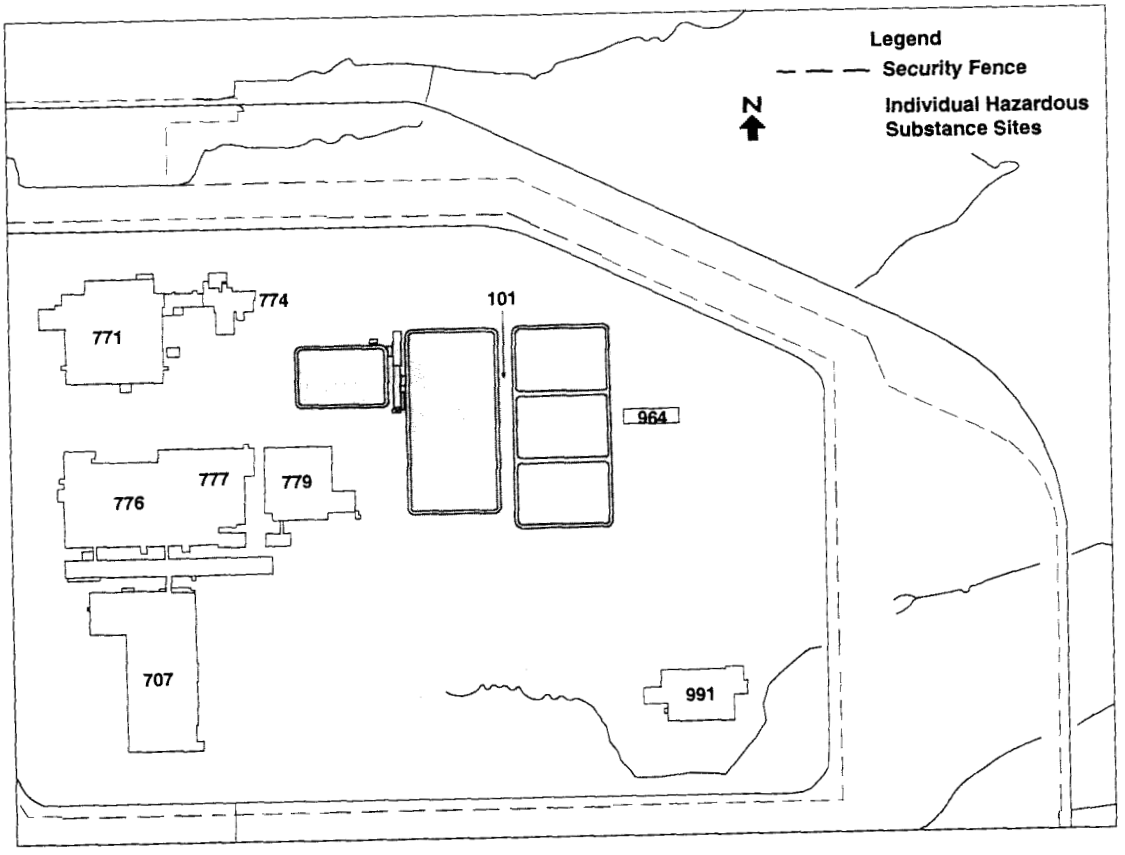


Figure 4-4. Operable Unit 4 - Solar Evaporation Ponds

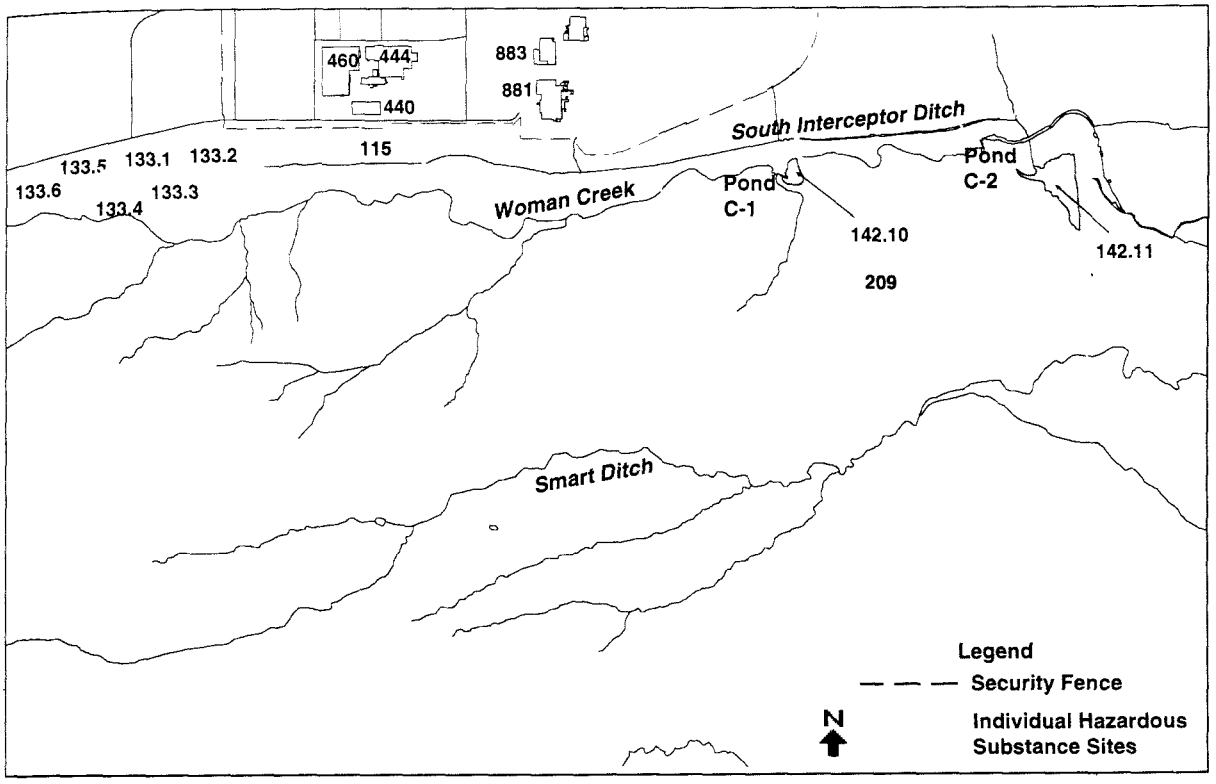


Figure 4-5. Operable Unit 5 - Woman Creek

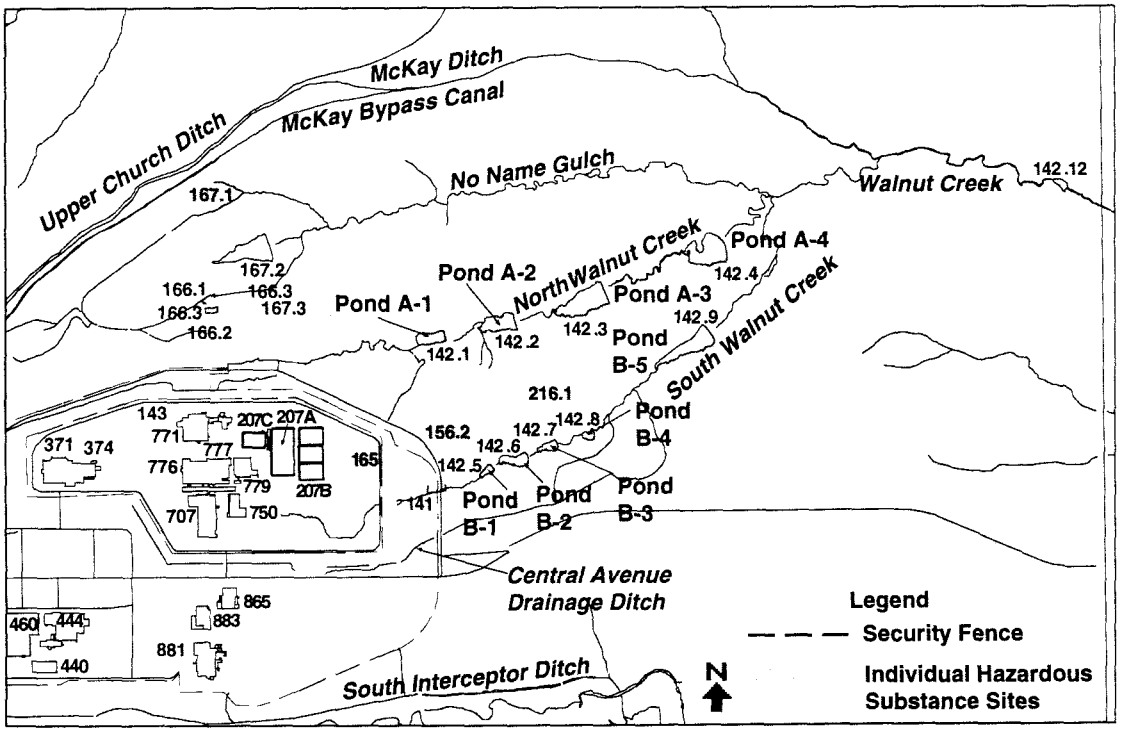


Figure 4-6. Operable Unit 6 - Walnut Creek

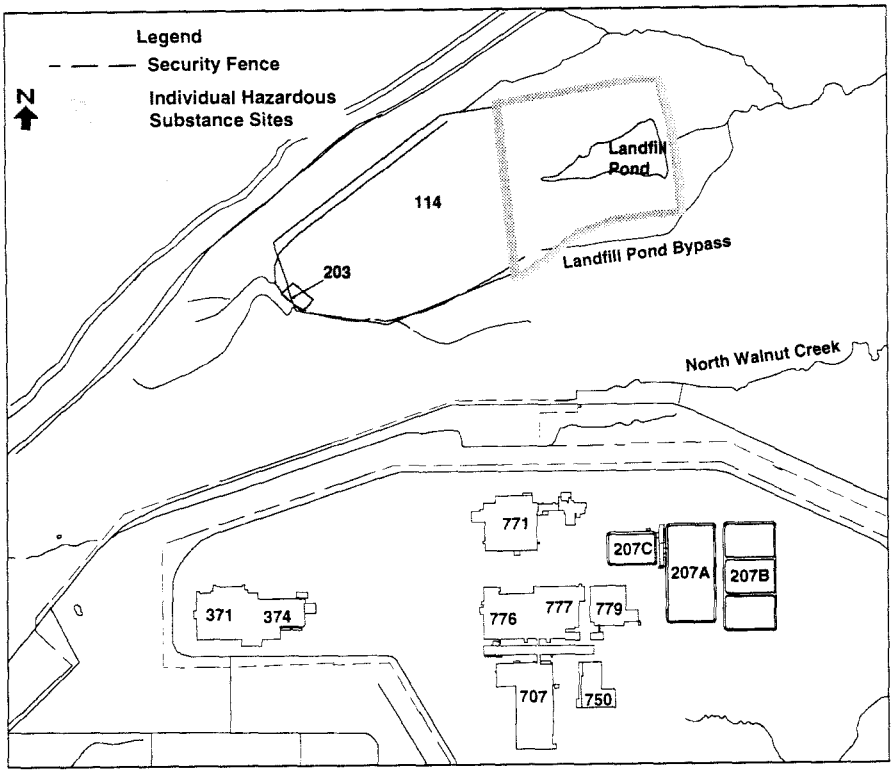


Figure 4-7. Operable Unit 7 - Present Landfill

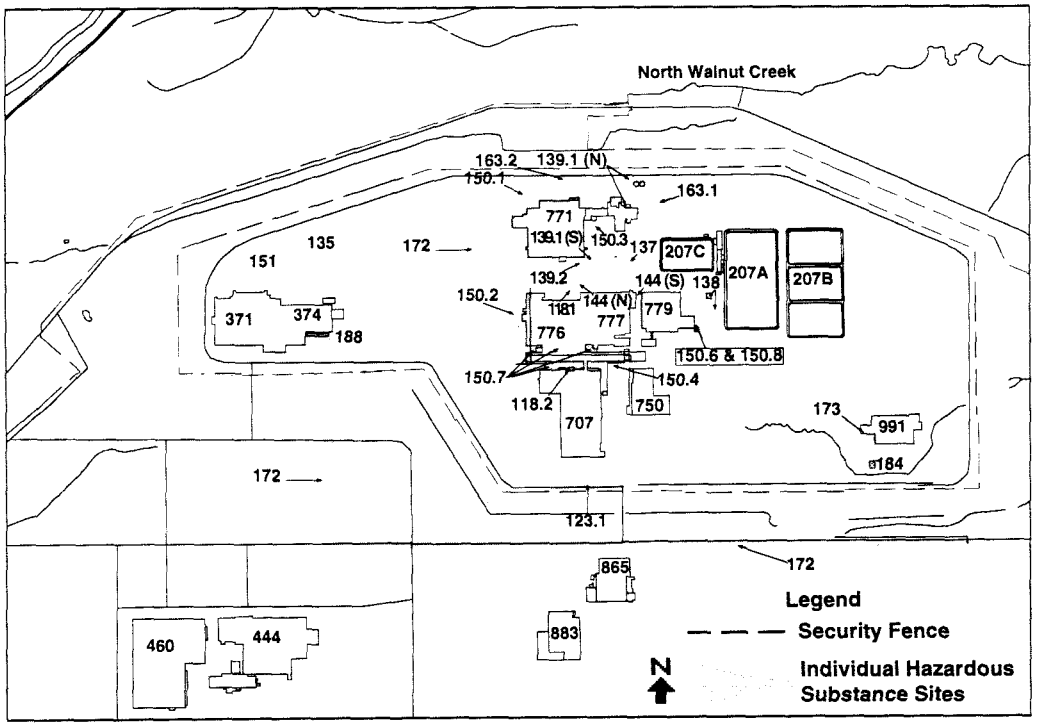


Figure 4-8. Operable Unit 8 - 700 Area

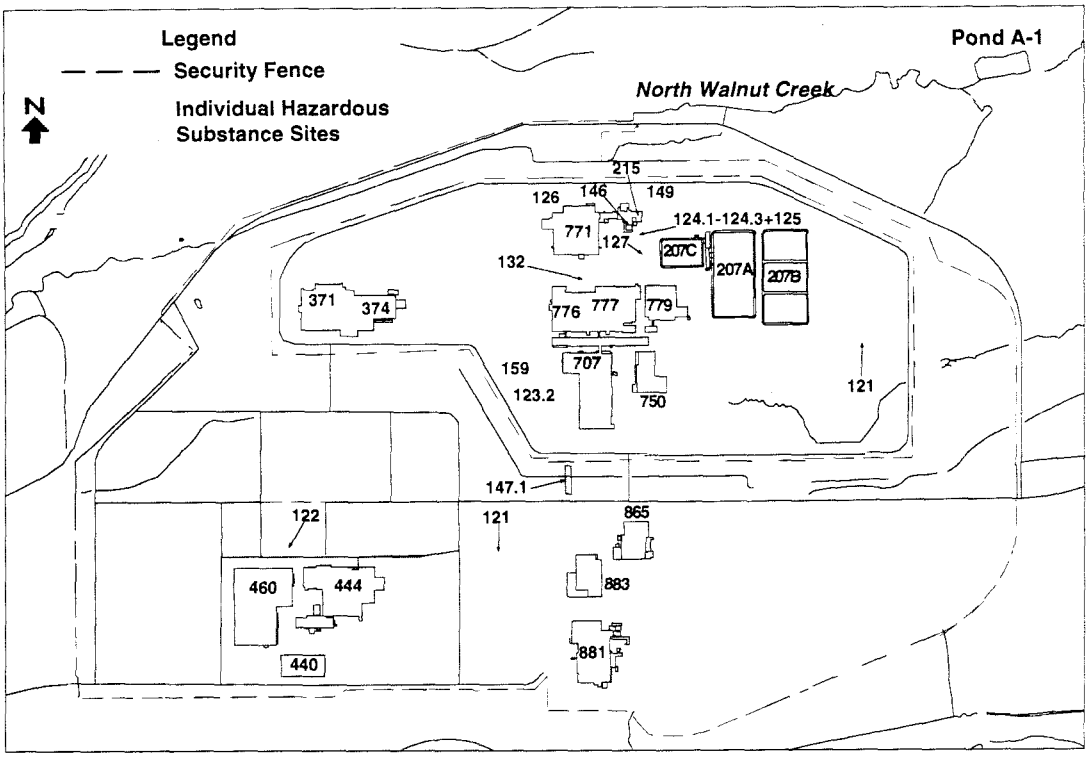


Figure 4-9. Operable Unit 9 - Original Process Waste Lines

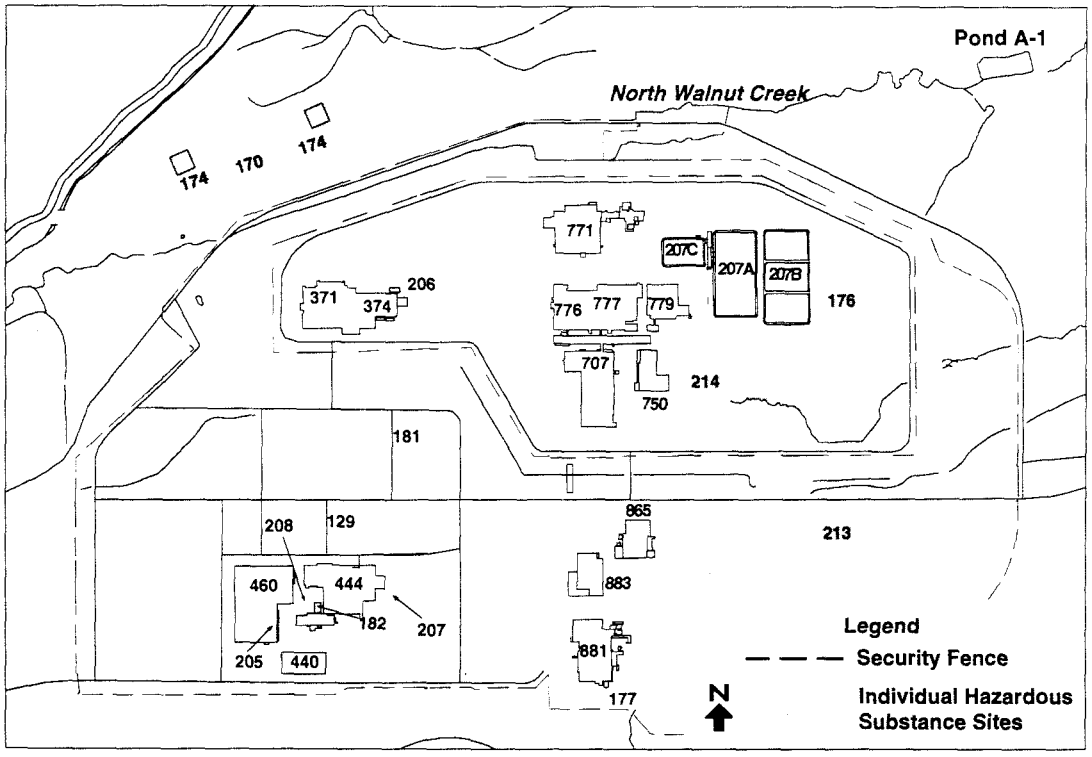


Figure 4-10. Operable Unit 10 - Other Outside Closures

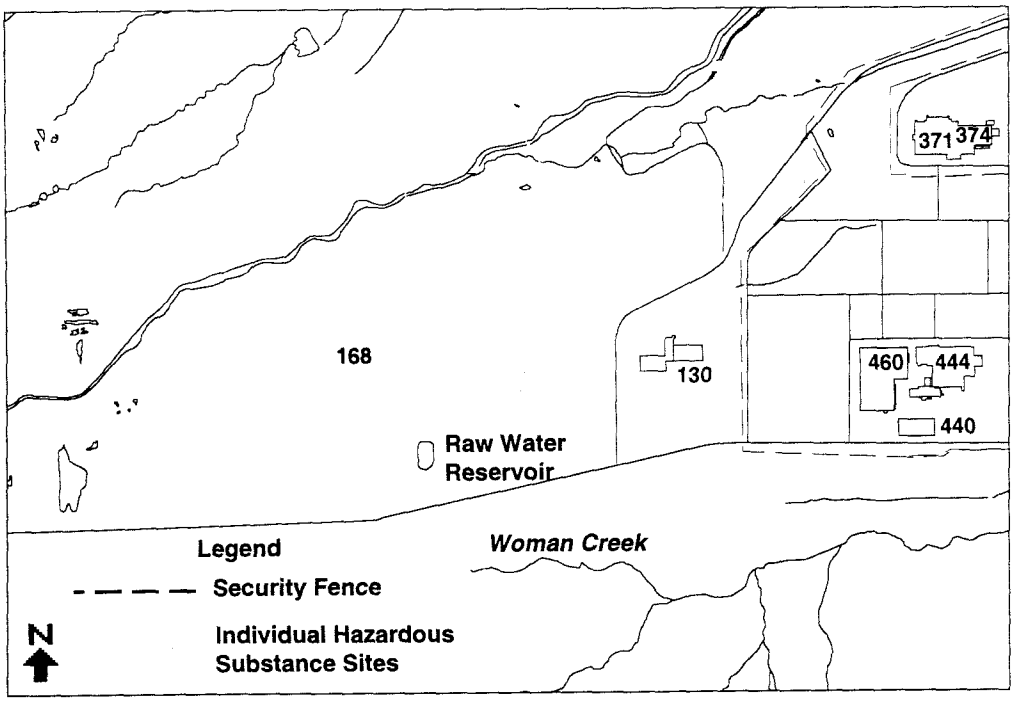


Figure 4-11. Operable Unit 11 - West Spray Field

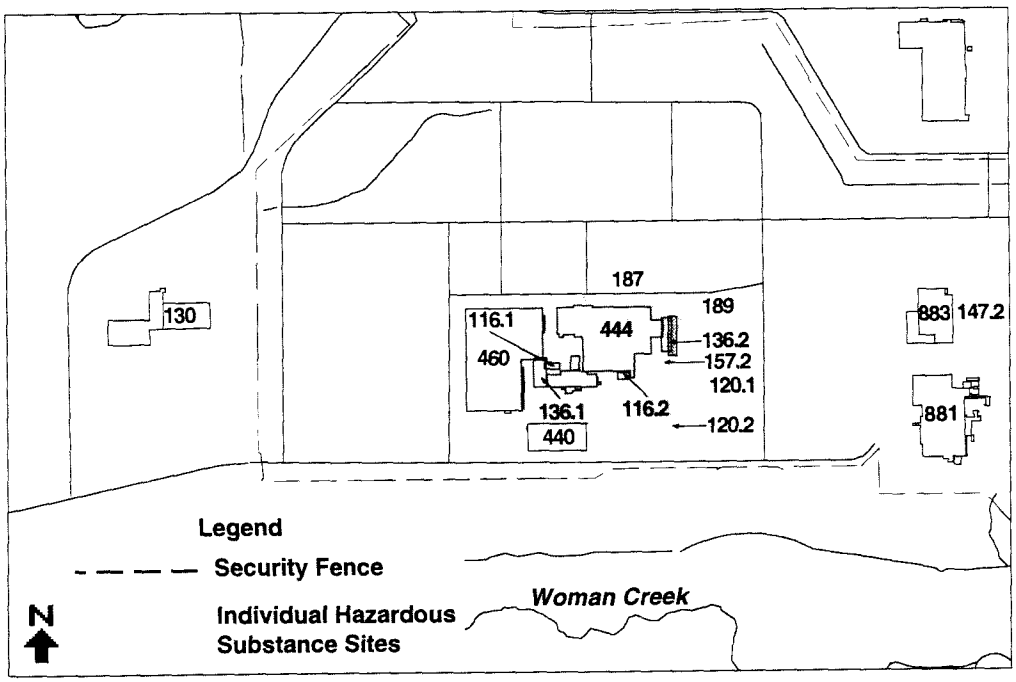


Figure 4-12. Operable Unit 12 - 400/800 Area

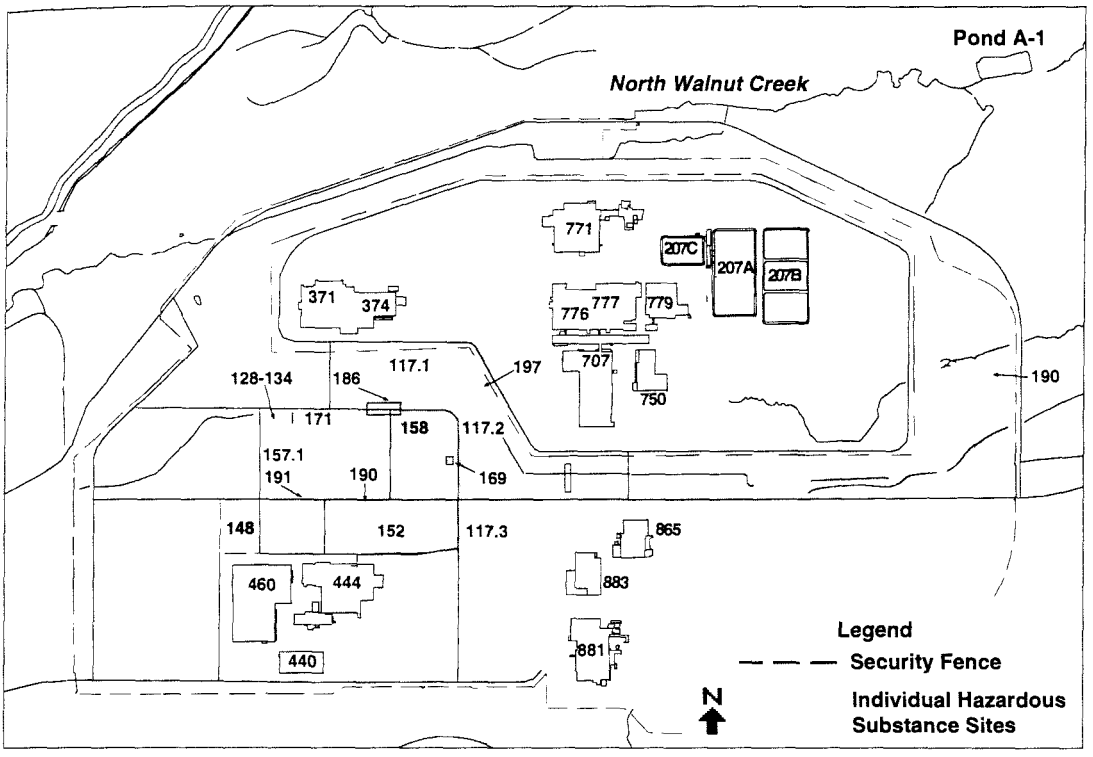


Figure 4-13. Operable Unit 13 - 100 Area

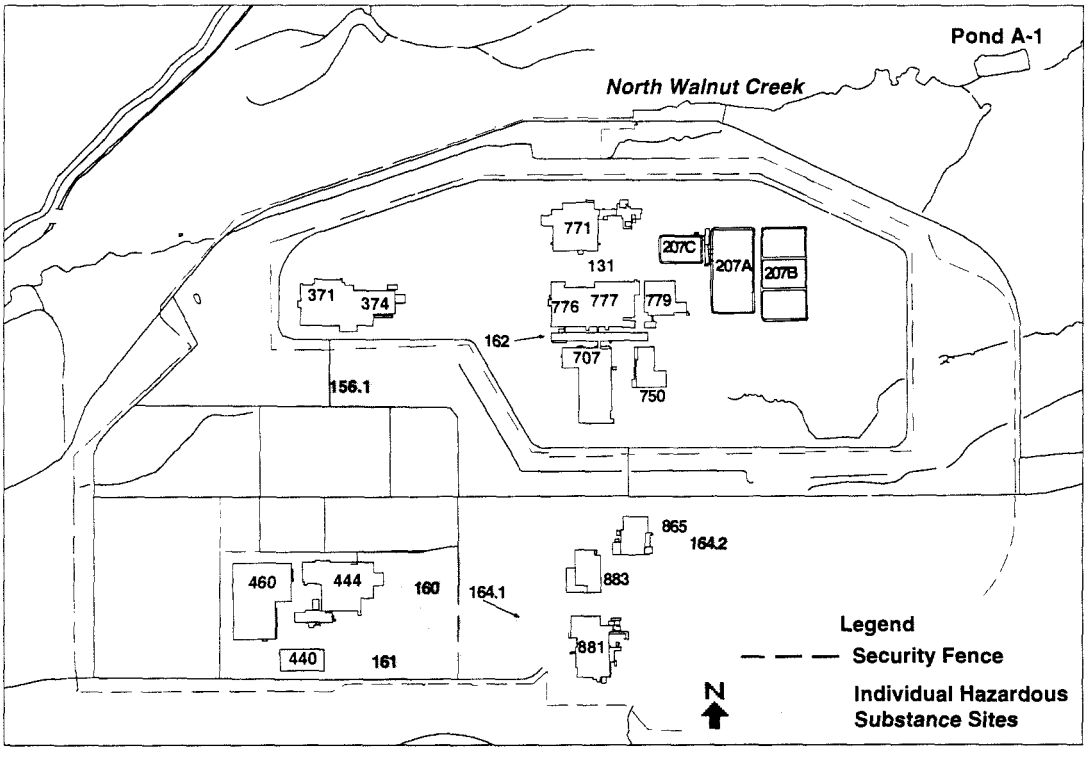


Figure 4-14. Operable Unit 14 - Radioactive Sites

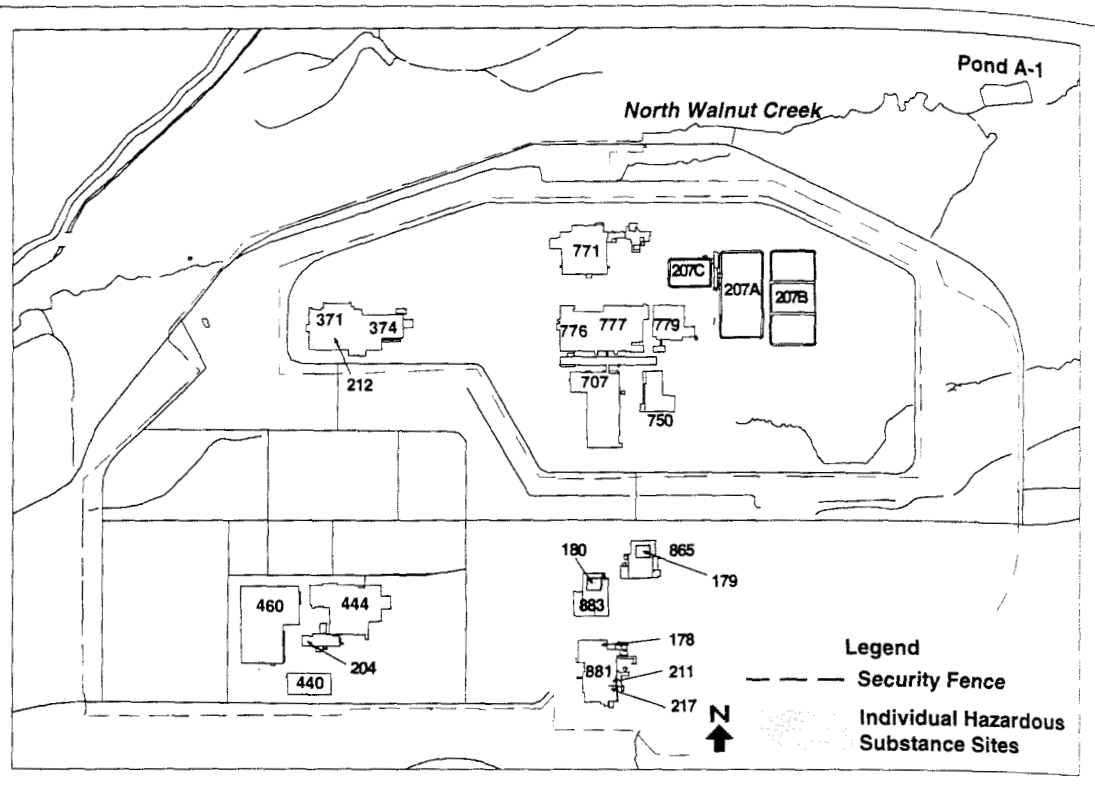


Figure 4-15. Operable Unit 15 - Inside Building Closures

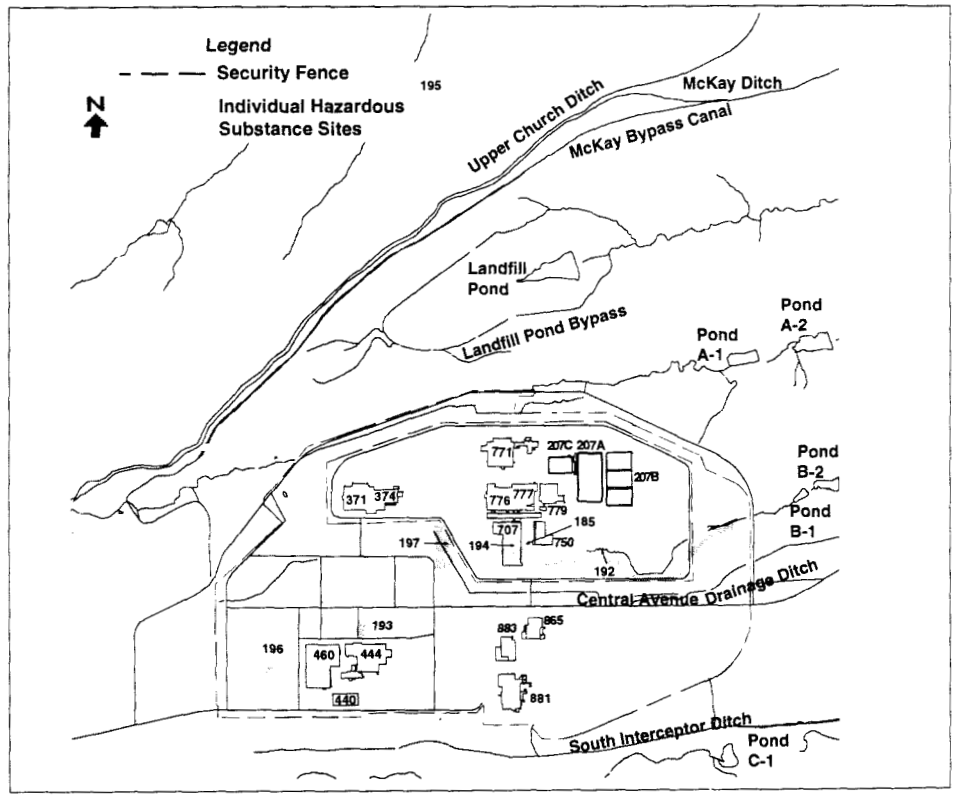
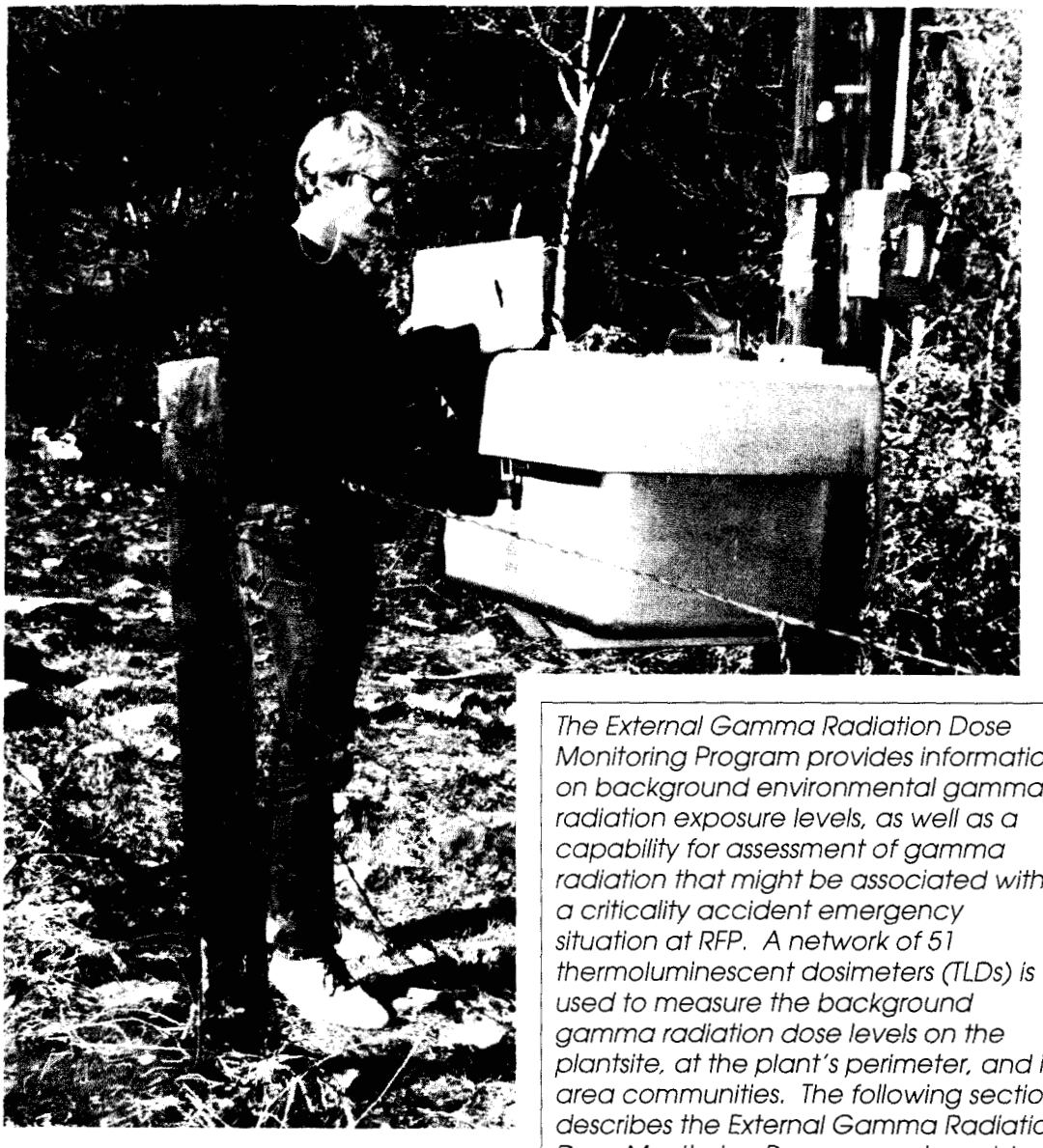


Figure 4-16. Operable Unit 16 - Low Priority Sites

5. External Gamma Radiation Dose Monitoring

Nancy M. Daugherty
Michael R. Klueber



The External Gamma Radiation Dose Monitoring Program provides information on background environmental gamma radiation exposure levels, as well as a capability for assessment of gamma radiation that might be associated with a criticality accident emergency situation at RFP. A network of 51 thermoluminescent dosimeters (TLDs) is used to measure the background gamma radiation dose levels on the plantsite, at the plant's perimeter, and in area communities. The following section describes the External Gamma Radiation Dose Monitoring Program and provides results of the TLD measurements recorded during 1992.

OVERVIEW

RFP activities emit relatively little penetrating gamma radiation to which the public might be exposed. The most important potential source of radiation dose to the public from RFP activities is alpha radiation that could potentially result from inhalation or ingestion of plutonium, americium, or uranium. Although alpha radiation is the most important source of radiation dose to the public from plant activities, RFP maintains a network of thermoluminescent dosimeters (TLDs) on the plantsite, at the plant's perimeter, and in area communities to measure external penetrating gamma radiation. Gamma radiation measured as part of the RFP program is primarily from naturally occurring cosmic and primordial sources.

TLDs contain a luminescent material that absorbs energy from exposures to ionizing radiation. When the TLD is later heated under controlled conditions, the energy is released as visible light. This light is measured and can be used to indicate the external gamma radiation dose that a person could receive under the same exposure conditions.

RFP has 51 TLD monitoring locations with replicate TLDs at each location. The newest location at the Standley Lake Library is part of the Community Radiation Monitoring Program (ComRad). This location was monitored for the last three quarters of 1992. Five of the 51 TLD locations are within Building 123 at RFP, the laboratory in which the TLDs are prepared and read out. All five locations are included in the reported onsite data. In addition, each location is reported separately.

During 1992, all TLDs were replaced following an exposure period of approximately 3 months. The TLDs are placed at 22 locations within the main plantsite, including the 5 locations within Building 123 (Figure 5-1). Measurements also are made at 16 perimeter locations 2 to 4 miles from the center of RFP (Figure 5-2) and in 13 communities located within 30 miles of RFP (Figure 5-3). The TLDs are placed approximately 3 feet above ground level.

In 1983, conversion from the Harshaw TLD system to a Panasonic TLD system was initiated at RFP. For one complete calendar year, two TLDs of each type were used at each monitoring location. Since 1984, only

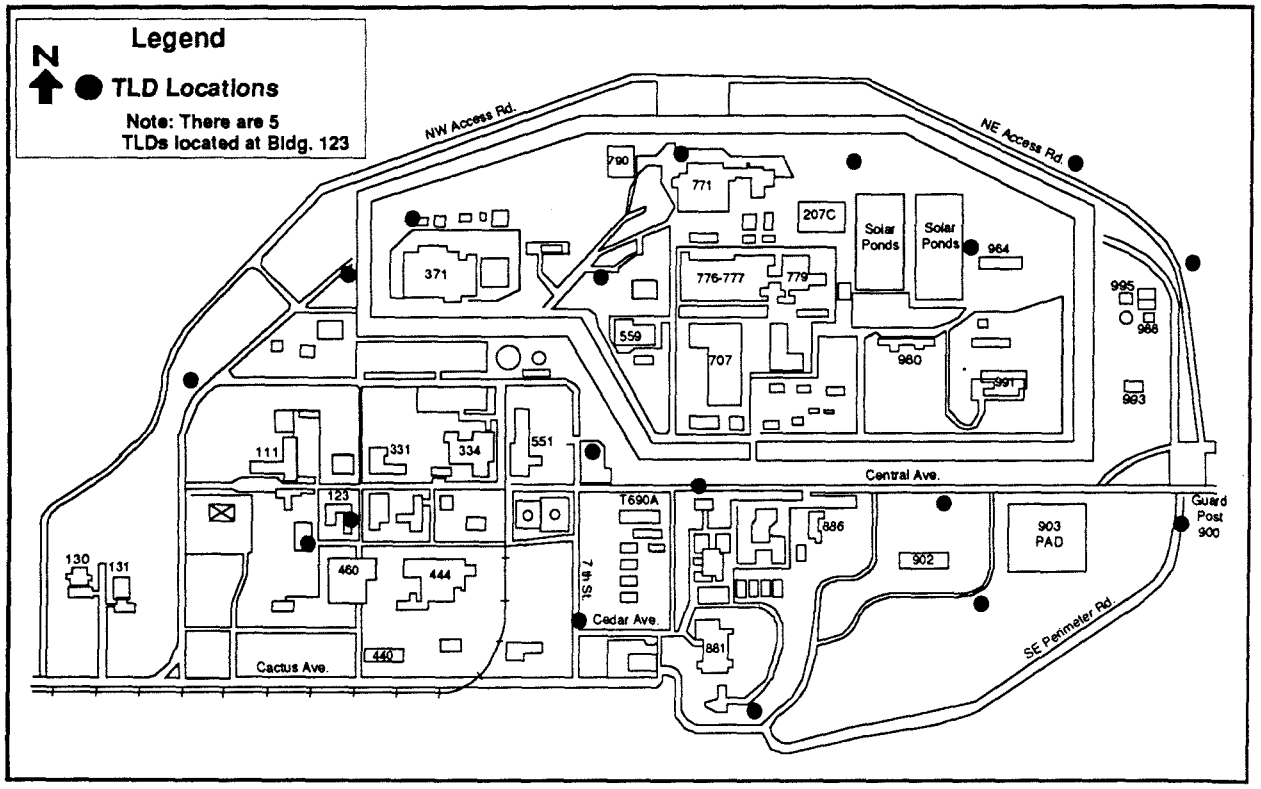


Figure 5-1. 22 TLD Locations within the Main Facilities Area

Panasonic TLDs have been used. It was determined that a statistically significant difference in response exists between the two systems. To compare Panasonic TLD data from 1984 through 1990 with the Harshaw system data reported prior to 1984, it is necessary to multiply the Panasonic results given in Table 5-1 by 1.046.

During 1991, new processing hardware and software were acquired for the Panasonic readers. A new multi-tasking, multi-user computer system that allows simultaneous data accumulation from several readers, as well as concurrent data processing, was put into service. This advanced system uses a new whole body dosimeter badge algorithm and new TLDs. The system, called the VAX/ISA system, passed rigorous DOE laboratory accreditation testing during the year and was recommended for accreditation.

During the first 4 months of the year, sets of TLDs from both the old and the new system were deployed in all of the environmental monitoring locations. A statistically significant difference exists between the results

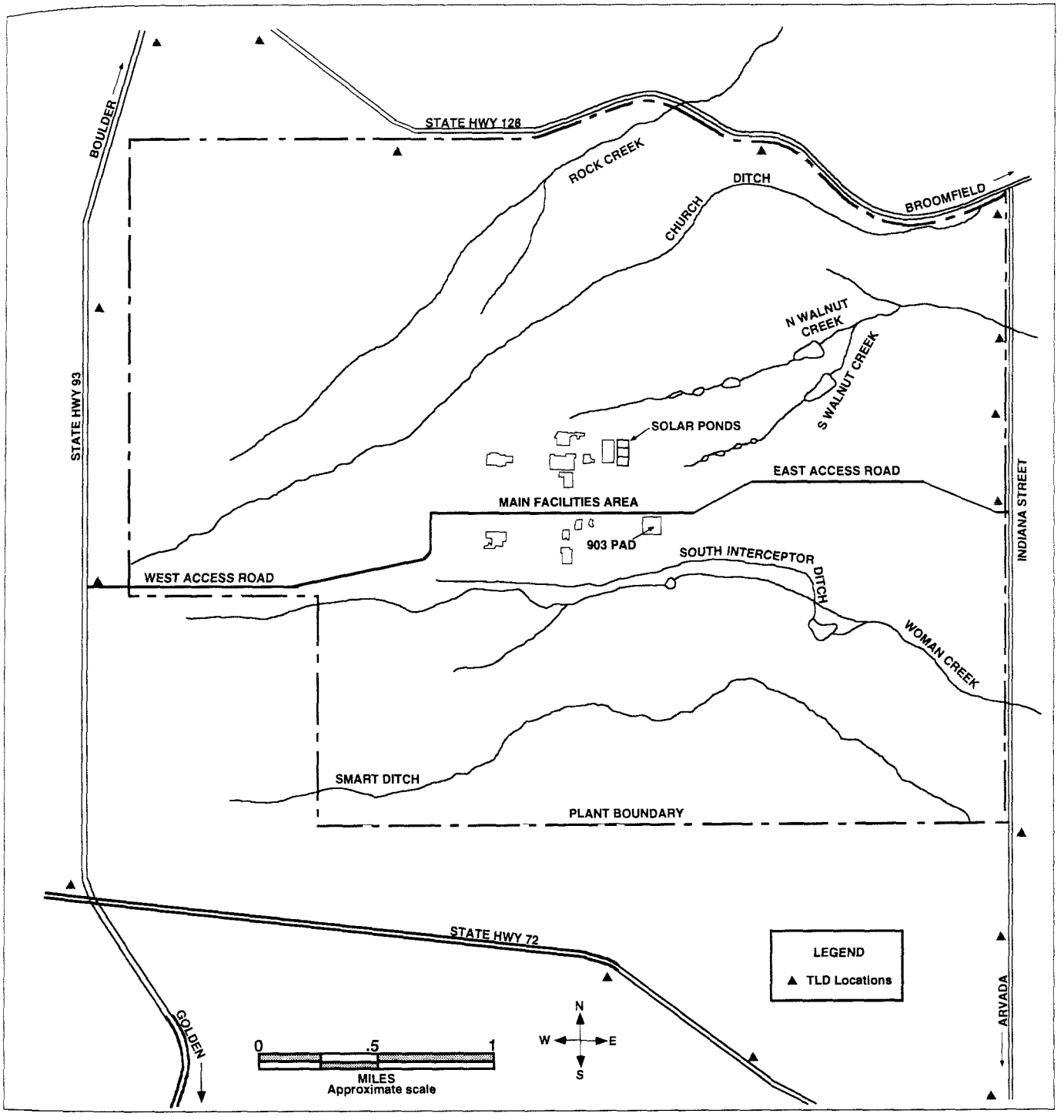


Figure 5-2. 16 TLD Locations Within a 2- to 4-Mile Radius of RFP

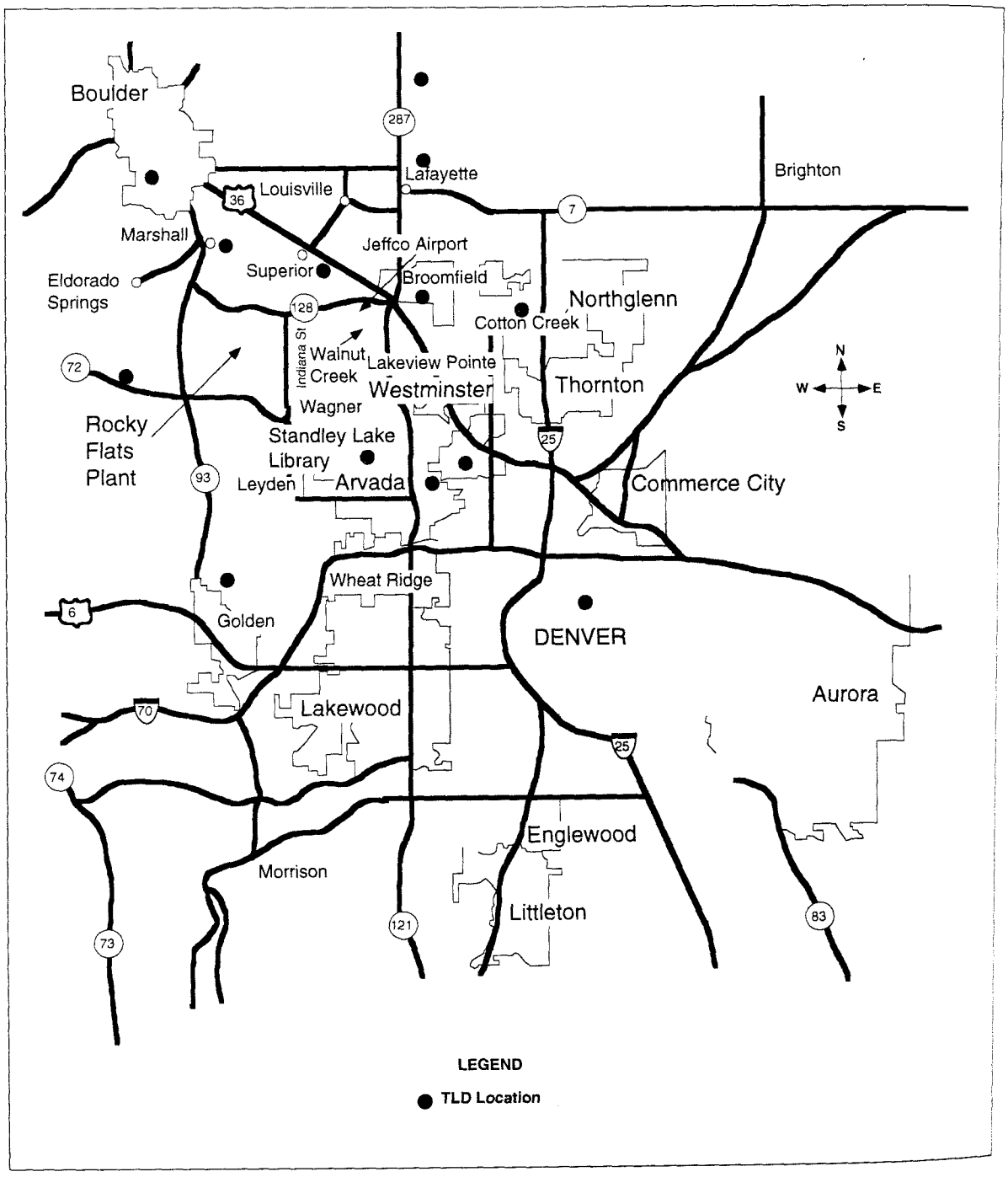


Figure 5-3. 13 TLD Locations in Communities Located Within a 30-Mile Radius of RFP

from the two systems. To compare the results obtained from the VAX/ISA system to the values obtained by the Panasonic system used before 1991, it is necessary to multiply the results for 1991 and 1992 by 1.3.

Several additional upgrades in the Environmental TLD Monitoring Program were initiated during 1992. New Panasonic TLDs specifically designed for environmental monitoring were purchased, a storage shield for the background TLDs (and TLDs not in use) was purchased, along with new plastic, gasketed holders for the TLDs. Testing was performed to determine the source of the statistical difference between the old Panasonic TLD processing system (used from 1984 through 1990) and the VAX/ISA new Panasonic TLD processing system that was phased into use during 1991. The testing showed that the new system was more accurate when compared to laboratory calibration irradiations. The most probable reason for this difference is that new TLDs with more accurate Element Correction Factors (ECFs) are being used with the new VAX/ISA Panasonic TLD processing system.

The Panasonic environmental TLDs in use for CY92 consist of two model UD-802AS dosimeters, each having four elements. Only one of the elements from each system is used. This element consists of calcium sulfate, thulium drifted (CaSO4:Tm), deposited on a polyamide surface. The phosphor is covered with a clear Teflon bubble. The TLDs are packaged in a small plastic bag, a paper envelope, and another plastic bag to protect them from the weather. Total filtration over the phosphor is 178.5 milligrams per square centimeter (mg/cm^2).

The TLDs are calibrated individually (three times each) against an onsite cesium-137 gamma calibration source. Calibration linearity studies have confirmed that TLD response is linear for exposure levels ranging from 10 mrem to 50 rem. The mean calibration factor for each dosimeter is applied to measurements taken with that dosimeter. In addition, quality control dosimeters are read with each group of TLDs to ensure that the variability in the readers is within the allowed tolerance.

The annual dose equivalent for each location category is calculated by determining the average millirem per day (mrem/day) for each of the three categories, using

data from the four quarters of 1992. These values are then multiplied by 365.25 to obtain yearly totals.

In previous annual reports, the annual measured dose was reported with a 95 percent confidence level on the mean, using the standard error of the mean, calculated from the variance of the individual measured values. Beginning in 1985, the 95 percent confidence interval on an individual observation within each location category, calculated as 1.96 standard deviations, was added to the report. This latter interval may be used for assessing the variability of the individual location measurements with a location category.

RESULTS

The 1992 environmental measurements using TLDs are summarized in Table 5-1. The average annual dose equivalents, as measured onsite, in the perimeter environments, and in local communities, were 121, 105, and 120 mrem (1.21, 1.05, and 1.20 milliSieverts [mSv]), respectively. These values are similar to those reported by the National Council on Radiation Protection and Measurements (NCRP) for background gamma radiation in the Denver area. The NCRP reported an annual range of 125 to 190 mrem (1.25 to 1.90 mSv) (NA87b). The average annual dose equivalent by monitoring location is provided in Tables 5-2, 5-3, and 5-4.

Table 5-1
Environmental Thermoluminescent Dosimeter Measurements

Location Category	Number of Locations	Number of Measurements	Mean Annual Measured Dose (mrem)	95% Confidence Interval on the Mean (mrem)[a]	95% Confidence Interval on an Individual Measurement (mrem)[b]
Onsite	22	176	121	±4	±52
Perimeter	16	128	105	±2	±21
Community	13	100	120	±3	±47

a. Calculated as 1.96 standard deviations of the mean.
b. Calculated as 1.96 standard deviations of the individual measurements.

Table 5-2

Onsite Environmental TLD Measurements[a]

Location	Average (mrem)	Standard Deviation
2	131	25
3	104	26
4	99	35
5	118	33
6	179	93
7	117	66
8	122	45
9	131	33
10	105	57
50	120	37
51	105	21
52	106	45
53	106	56
54	119	22
55	138	21
56	109	47
134	114	47
135	122	61
136	130	33
137	119	44
1A	142	52
R133	114	20

a. Average mrem = 121
1.96 standard deviations of the individual measurements = 52
1.96 standard deviations of the mean = 4

Table 5-3

Perimeter Environmental TLD Measurements[a]

Location	Average (mrem)	Standard Deviation
18	101	59
26	110	24
27	111	30
28	110	40
32	113	23
33	124	20
34	119	20
35	109	30
36	98	42
37	103	39
38	105	37
39	96	55
81	105	29
82	91	69
83	94	76
84	99	37

a. Average mrem = 105
1.96 standard deviations of the individual measurements = 21
1.96 standard deviations of the mean = 2

Table 5-4

Community Environmental TLD Measurements[a]

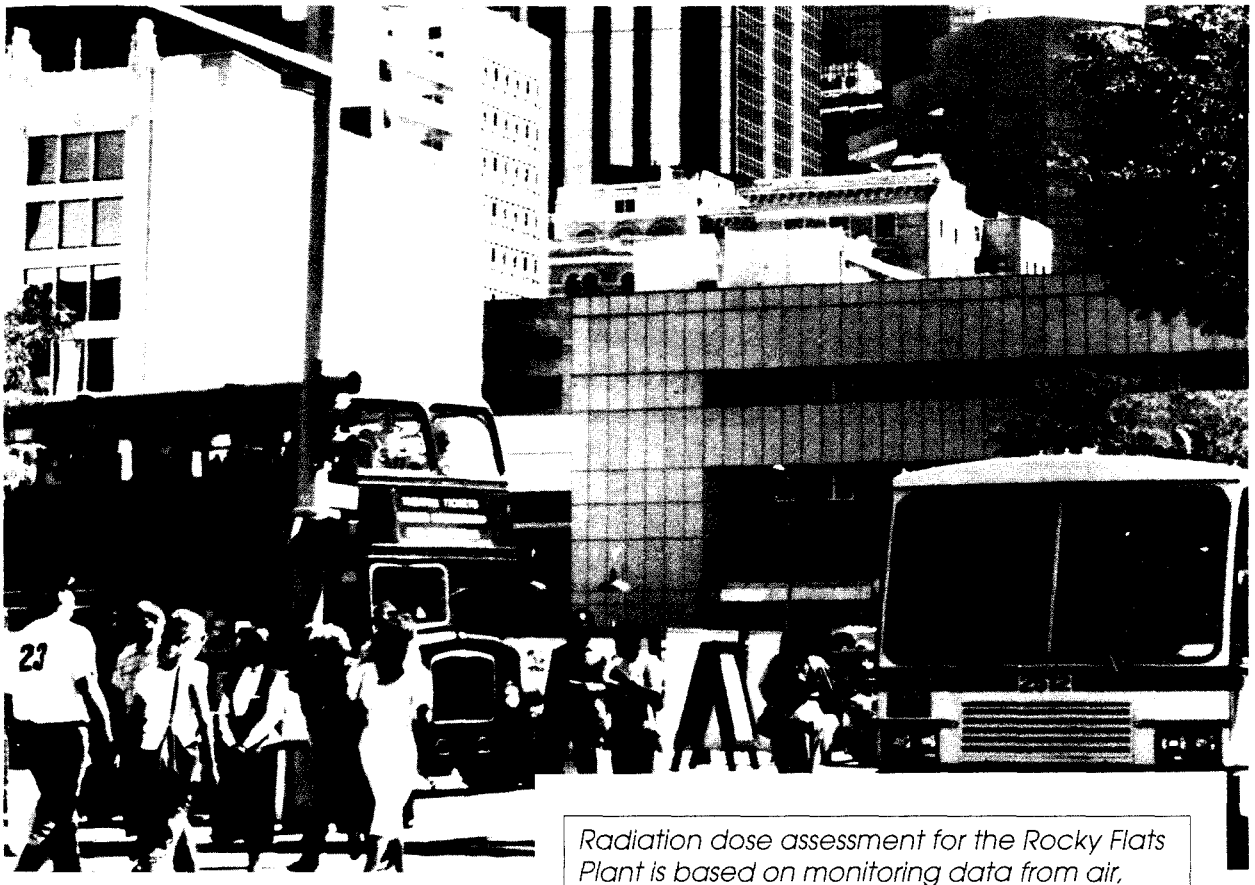
Location	Community	Average (mrem)	Standard Deviation
S11	Coal Creek	119	23
S13	Marshall	107	89
S14	Arvada	134	18
S15	Boulder	124	28
S16	Lafayette	132	52
S17	Broomfield	114	67
S19	Longmont	135	37
S20	Golden	112	60
S23	Denver	132	24
S25	Westminster	117	51
S31	Superior	107	42
S90	Northglenn	102	35
SLL[b]	Standley Lake Library	126	34

a. Average mrem = 120
1.96 standard deviations of the individual measurements = 47
1.96 standard deviations of the mean = 3

b. ComRad, Standley Lake Library location.

6. Radiation Dose Assessment

Nancy M. Daugherty



Radiation dose assessment for the Rocky Flats Plant is based on monitoring data from air, water, and soil sampling programs. The 1992 assessment of dose to the public from RFP activities indicates that the radiation dose to the maximally exposed individual in the public is estimated to be 0.46 millirem effective dose equivalent (EDE). For comparison, the average person in the United States receives approximately 300 millirem EDE from natural background radiation sources.

ROCKY FLATS PLANT RADIOACTIVE MATERIALS

Radioactive materials included in estimating radiation dose to the public from RFP activities are plutonium, uranium, americium, and tritium. Plutonium and americium in RFP environs are the combined result of residual fallout deposition from global atmospheric nuclear weapons testing and releases from the plant. Uranium, a naturally occurring element, is indigenous to many parts of Colorado and is used in RFP operations in various isotopic ratios. Tritium, which is both naturally occurring and produced artificially, is sometimes handled in RFP operations.

In the dose assessment performed for CY92, internal exposure to alpha radiation emissions from water ingestion of plutonium, uranium, and americium is the primary contributor to the projected radiation dose.

The 1992 radiation dose assessment includes modifications to assumptions used in pre-1991 annual site environmental reports for potential pathways of exposure to the public. The 1992 assumptions are intended to reflect potential exposure conditions more accurately. In pre-1991 annual RFP site environmental reports, the approach taken for dose assessment was extremely conservative, based on assumptions for a hypothetical individual that would tend to maximize the resulting dose estimate, but which were known to be unrepresentative of actual living habits in the RFP area. DOE Order 5400.5 encourages the use of more realistic, but still conservative, approaches to dose assessment. The approach documented in this 1992 report is believed to be more realistic than in previous reports in reflecting actual residential areas and pathways of exposure in the RFP vicinity. However, the 1992 report approach continues to employ conservative assumptions of intake rates, exposure duration, and solubility of radioactive contaminants. Adding to the conservatism is the lack of subtraction of background (non-RFP related) contributions of radioactive contaminants in air and soil concentrations and in water concentrations for radionuclides other than uranium.

The assumptions made for the water ingestion pathway also continue to be conservative. The source of potential water ingestion, Pond C-2 discharges, was chosen to provide an upper bound to radioactivity concentrations for water ingestion, although it is known that no individual is actually using Pond C-2 as a drinking water supply at this location. Throughout 1992, RFP

surface water was not discharged directly to any public drinking water supply. As data for other monitoring locations become available in the future, more realistic assumptions regarding this pathway may be made. Background subtraction is performed only for uranium concentrations in this water source term. Correction for background uranium concentrations in water is made because of the large relative contribution to this pathway from naturally occurring uranium.

Beginning in 1991, direct ingestion of soil was added to the exposure scenario, consistent with recommendations by the EPA for performance of risk assessments (EPA89a).

Previous pathway assessments in the *Environmental Impact Statement, Rocky Flats Plant Site* indicate that swimming and consumption of foodstuffs are relatively insignificant contributors to public radiation dose (DOE80). Swimming and fishing are limited in the area, and most locally consumed food is produced at considerable distances from the plant. A pathway analysis review performed under contract to RFP by the Colorado State University Department of Radiological Health Sciences confirmed the relative insignificance of these pathways (FR92).

The results of the 1992 assessment of dose to the public from RFP activities indicate that the radiation dose to the maximally exposed individual in the public is estimated to be 0.46 millirem (4.6×10^{-3} mSv) effective dose equivalent (EDE). The collective population dose to a distance of 80 kilometers (50 miles) is estimated as 0.1 person-rem (1×10^{-3} person-sievert [Sv]). These calculated radiation doses are believed to be conservative estimates that would be an upper bound for any radiation doses actually received by the public. The greatest contributor (more than 83 percent) to the estimated dose to the maximally exposed individual is ingestion of uranium (62 percent), plutonium (19 percent), and americium (2 percent) in water. More specific information regarding the 1992 radiation dose assessment follows.

Radiation Protection Standards for the Public

Standards for protection of the public from radiation are based on radiation dose, which is a means of quantifying the biological effect or risk of ionizing radiation. In the United States, the unit commonly used to

express radiation dose is the rem or the millirem (1 rem = 1,000 mrem). The comparable International System (SI) unit of radiation dose is the sievert (1 sievert [Sv] = 100 rem). Radiation protection standards for the public are annual standards, based on the projected radiation dose from a year's exposure to or intake of radioactive materials.

Radiation protection standards applicable to DOE facilities are based on recommendations of national and international radiation protection advisory groups and on radiation protection standards set by other federal agencies. On February 8, 1990, DOE adopted revised radiation protection standards for DOE environmental activities (DOE90a). These standards incorporate guidance from the NCRP, the International Commission on Radiological Protection (ICRP), and the EPA Clean Air Act NESHAP, as implemented in 40 CFR 61, Subpart H (EPA85). Effective December 15, 1989, EPA revised NESHAP standards for airborne emissions of radionuclides from DOE facilities (EPA89a). These new NESHAP standards apply to air emissions from RFP in 1992 and are incorporated into the revised DOE standards.

Table 6-6 and Appendix B, Table B-1, summarize the revised DOE radiation protection standards for the public as established in 1990. The revised NESHAP standards of December 15, 1989, are included.

Radiation Dose

In this 1992 dose assessment, radiation *dose* is calculated by multiplying radioactivity concentrations in air, water, and soil by assumed intake rates (for internal exposures) or exposure times (for external exposure to penetrating radiation). These products then are multiplied by the appropriate radiation dose conversion factors as follows:

Radiation Dose =
(Radioactivity Concentration) X
(Intake Rate or Exposure Time) X
(Radiation Dose Conversion Factor)

In calculating radiation *dose equivalent*, differences in the biological effect of different types of ionizing radiation (e.g., alpha, beta, gamma rays, or X-rays) are accounted for in the dose conversion factor. Radiation energy absorbed in the tissue of interest is calculated and then multiplied by a modification factor based on

the type and energy of the ionizing radiation involved. One millirem of dose equivalent from alpha radiation would have the same biological effectiveness on a particular organ as one millirem of dose equivalent from gamma radiation. Dose equivalent can be calculated for the whole body when there is uniform irradiation of all tissues, or for individual organs when selected tissues are irradiated nonuniformly.

In 1985, DOE adopted radiation protection standards for the public based on the concept of EDE. The December 15, 1989, EPA NESHAP standards also incorporate EDE as the basis for radiation protection for the public from airborne emissions of radioactivity. Previously, whole body dose equivalent and individual organ dose equivalent, as described above, were used for this purpose. The following dose assessment for 1992 uses EDE as the basis for radiation protection of the public, but it includes some individual organ dose equivalents for comparison with previous RFP annual reports.

EDE is a means of calculating radiation dose that allows comparisons of the total health risk of cancer mortality and serious genetic effects from exposures of different types of ionizing radiation to different body organs. EDE is calculated by first determining the dose equivalent to those organs receiving significant exposures, multiplying each organ dose equivalent by a health risk weighting factor, and summing those products. The health risk weighting factors used in the calculation of EDE normalize the risk against a whole body radiation dose. Therefore, the health risk (from cancer mortality and genetic damage) that is associated with 1 mrem of EDE is comparable to the risk associated with 1 mrem of whole body dose equivalent. Likewise, 1 mrem of EDE from natural background radiation would have the same health risk as 1 mrem of EDE from artificially produced sources of radiation, regardless of which organ(s) receives the dose.

Radioactivity Concentration

Radioactivity concentrations or source terms used in calculating dose can be determined from actual samples and measurements in the environment taken at the locations of interest. Alternatively, for airborne releases, these concentrations can be calculated by modeling the atmospheric dispersion of air emissions from buildings and contaminated land areas.

In the following dose assessment, actual environmental measurements near locations of interest are used to determine compliance with the DOE radiation standard for all pathways. These measurements are used to calculate annual average concentrations of radioactive materials in air and soil at the RFP boundary and for the water pathway at the Pond C-2 discharge point.

As required in federal regulation 40 CFR 61, an EPA-approved computer code is used to determine compliance with CAA NESHAP radionuclide emissions standards for the air pathway only. The EPA-approved code, CAP88-PC, includes air dispersion modeling of measured air emissions from buildings and contaminated land areas, as well as dose conversion factors for calculating final radiation dose.

Intake Rate or Exposure Time

Intake rates of radioactive materials used to represent air inhalation and water ingestion for 1 year are prescribed by the DOE (DOE88b, DOE90a). The rates for air and water are based on recommendations of the ICRP (IN75). The breathing and water ingestion rates for 1 year are 8,400 cubic meters and 730 liters, respectively. The EPA provides recommendations for soil ingestion rates in *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (EPA89b). The EPA guidance for direct ingestion of soil by an adult is 100 milligrams per day. Exposure times for external penetrating radiation are assumed to be 1 year, as prescribed by DOE (DOE 90a).

Radiation Dose Conversion Factors

Radiation dose conversion factors used for determining compliance with DOE standards for all pathways are prescribed by DOE (DOE88a, DOE88b, DOE90a). Dose conversion factors for internal exposures are based on recommendations of the ICRP (IN79). Dose conversion factors for external exposures to penetrating radiation are based on a methodology developed at Oak Ridge National Laboratory (ORNL) (KO81, KO83), with modifications by the original author (DOE88a).

The plutonium handled at RFP is a mixture of plutonium isotopes having different atomic masses and may include americium-241. Relative abundances of plutonium and americium isotopes in plutonium typically used at RFP (Table 6-1) were used to calculate composite dose conversion factors for plutonium and

americium in air and for plutonium in water and soil. The relative abundances used in developing the composite dose conversion factors were based on the isotopic activity fractions of plutonium-239 and -240, since these are the isotopes measured in environmental monitoring sample analyses. Fractions of ingested radionuclides absorbed from the gastrointestinal tract and lung clearance classes for inhaled radionuclides were chosen to maximize the associated internal dose conversion factors and the resulting radiation dose. Each internal dose conversion factor is for a 50-year dose commitment from 1 year of chronic exposure; that is, the dose that an individual could receive for 50 years following 1-year's chronic intake of radioactive material is calculated. The dose conversion factors used in this assessment are listed in Table 6-2. These dose conversion factors incorporate the intake rates and exposure times discussed above.

Table 6-1

Isotopic Composition of Plutonium Used at the RFP

Isotope	Relative Weight (Percent)	Specific Activity (Ci/g)	Relative Activity[a] (Ci/g)	Fraction of Pu Alpha Activity[b]	Fraction of Pu-239, -240 Activity[c]
Pu-238	0.01	17.1	0.00171	0.0233	0.0239
Pu-239	93.79	0.0622	0.05834	0.7962	0.8153
Pu-240	5.80	0.228	0.01322	0.1804	0.1847
Pu-241	0.36	103.5[d]	0.37260[d]	5.085[d]	5.207
Pu-242	0.03	0.00393	1.18×10^{-6}	1.61×10^{-5}	1.65×10^{-5}
Am-241	-	-	-	0.20[e]	0.205

a. Obtained by multiplying the relative weight percent by the specific activity.
b. Obtained by dividing the relative activity by the sum of the relative activities for the plutonium alpha emitters.
c. Obtained by dividing the relative activity by the sum of the relative activities of Pu-239 and Pu-240.
d. Beta activity.
e. The value for Am-241 is taken to be 20 percent of the plutonium alpha activity.

Table 6-2

Dose Conversion Factors Used in Dose Assessment Calculations for the RFP in 1992

INHALATION $\frac{\text{Rem * Milliliter}}{\text{Microcurie}}$ [a,b]

Organ	Pu-239, -240
Effective Dose Equivalent	5.71×10^{12}
Liver	2.22×10^{13}
Bone Surfaces	1.04×10^{14}
Lung	1.08×10^{13}

SOIL INGESTION $\frac{\text{Rem * Gram}}{\text{Picocurie}}$ [a,g]

Organ	Pu-239,-240	Am-241
Effective Dose Equivalent	1.77×10^{-4}	1.64×10^{-4}
Liver	6.58×10^{-4}	6.21×10^{-4}
Bone Surfaces	3.21×10^{-3}	2.96×10^{-3}
Lung	(f)	(f)

WATER INGESTION $\frac{\text{Rem * Milliliter}}{\text{Microcurie}}$ [a,c]

Organ	Pu-239,-240	Am-241	U-233,-234	U-238
Effective Dose Equivalent	3.53×10^{6}	3.29×10^{6}	1.90×10^{5}	1.70×10^{5}
Liver	1.32×10^{7}	1.24×10^{7}	(e)	(e)
Bone Surfaces	6.42×10^{7}	5.91×10^{7}	2.99×10^{6}	2.70×10^{6}
Lung	(f)	(f)	(f)	(f)

GROUND-PLANE IRRADIATION $\frac{\text{Rem * Square Meter}}{\text{Microcurie}}$ [d]

Organ	Pu-239,-240	Am-241
Effective Dose Equivalent	4.80×10^{-5}	2.99×10^{-3}
Liver	4.53×10^{-6}	1.78×10^{-3}
Bone Surfaces	1.62×10^{-5}	3.69×10^{-3}
Lung	9.78×10^{-6}	2.01×10^{-3}

a Inhalation, water, and soil ingestion dose conversion factors were adapted from DOE/EH-0071 (DOE88b) and are for a 50-yr dose commitment period and a 1-micrometer (μm) Activity Median Aerodynamic Diameter (AMAD) particle size. Gastrointestinal (GI) absorption fractions and lung clearance classes were chosen to maximize the dose conversion factors.

b. An inhalation rate of 2.66×10^{2} milliliters per second (ml/s) for 1 year was assumed and incorporated into the dose conversion factor.

c. A water intake rate of 2×10^{3} ml (2.1 quarts) per day for 1 year was assumed.

d. Ground-plane irradiation dose conversion factors were adapted from DOE/EH-0070 (DOE88a). For Pu-239 and -240, the higher of the factors for the two isotopes was used. A 1-year exposure period was assumed.

e. The liver receives no significant dose from this pathway.

f. The lung receives no significant dose from this pathway.

g. A soil ingestion rate of 100 milligrams per day for 1 year was assumed and incorporated into the dose conversion factor.

The EPA-approved computer code CAP88-PC, used to determine compliance with the CAA NESHAP standard for the air pathway, incorporates EPA's own approved dose conversion factors. Measured plutonium emissions were modeled for the isotopes plutonium -238 and plutonium-239, -240. Specific analyses for plutonium-241 and -242 are not performed on environmental samples, but these isotopes would be relatively insignificant contributors to total dose. Plutonium-241 emits primarily beta radiation with a very small internal dose conversion factor; plutoni-um-242 emits primarily alpha radiation, but is a small component of the total plutonium activity mix (Table 6-1). The CAP88-PC default values for lung clearance class and gastrointestinal uptake fraction were used when running this code.

Maximum Plant Boundary Dose

Dose assessment for 1992 was conducted for the RFP property boundary and several sites to a distance of 80 kilometers (50 miles). DOE Order 5400.5 (DOE90a) requires that doses calculated for demonstration of compliance with applicable standards "...be as realistic as practicable. Consequently, all factors germane to dose determination should be applied. Alternatively, if available data are not sufficient to evaluate these factors or if they are too costly to determine, the assumed parametric values shall be sufficiently conservative so that it is unlikely that individuals would actually receive a dose that would exceed the dose calculated using the values assumed."

In pre-1991 annual RFP site environmental reports, the approach taken for dose assessment was extremely conservative based on assumptions for a hypothetical individual that would tend to maximize the resulting dose estimate; however, these assumptions were known to be unrepresentative of actual living habits in the RFP area. For example, it was assumed that the hypothetical member of the public was residing continuously during the year at the RFP boundary at the location for which the highest average plutonium in air concentration was measured for the year. The location might change from year to year, depending on where that maximum concentration was measured. The maximum plutonium and americium soil concentrations measured near the RFP boundary were used in calculating potential exposure from contaminated soil, even though no individual actually lived near the location for those maxima.

In this 1992 report, more realistic, but still conservative, assumptions are made for dose assessment in conformance with the DOE Order 5400.5 guidance. Environmental monitoring data are used from sample locations nearer areas of actual residence. The nearest housing to RFP is located near the southeast boundary of the plant. Sampling locations were chosen that are near this boundary but generally upwind or upgradient of existing housing, and between the housing and RFP processing facilities. Following is a description of the radionuclide concentrations (source terms) used for calculating the maximum radiation dose to the public for all pathways and the results of that calculation.

The soil ingestion source terms and the ground-plane source terms of penetrating radiation exposure from contaminated soil areas are based on measured concentrations of plutonium in soil and an assumed ratio of 0.20 for the americium-241 to plutonium-239, -240 activity. Inhalation source terms for the 1992 dose assessment were based on plutonium-239, -240 concentrations measured in ambient air samples. Although it is known that some of this plutonium in soil and air is from residual fallout from past global atmospheric weapons testing, for the purposes of this dose assessment it was conservatively assumed that all plutonium originated from RFP.

The maximum site boundary dose assessment assumes that an individual is present continuously at the RFP perimeter. This assumption of an individual residing continuously at the plant boundary is used to provide a conservative upper bound on any radiation dose to the public that might originate from RFP.

The plutonium inhalation source term of 1.6×10^{-18} µCi/ml (6.1×10^{-8} Bq/m^3) was the annual average concentration of plutonium-239 and -240, as measured at the S-38 location in the perimeter ambient air sampling network. The S-38 location is the closest plant perimeter air sampling location upwind of housing located nearest to the plant in the southeast direction. This housing is near the RFP boundary.

The water supply for a hypothetical individual at the RFP boundary was assumed to be Pond C-2, which receives surface-water runoff and, potentially, some seepage of contaminated alluvial groundwater from RFP. Pond C-2 is intermittently discharged offsite. It should be noted that the assumption that someone may

drink this water is extremely conservative, leading to an overestimate of dose to the individual. No individual uses Pond C-2 water effluent at its discharge point as a finished drinking water supply, and during 1992 no surface-water effluent from RFP went directly to any drinking water supply. Plant surface-water effluents were diverted around Great Western Reservoir and Standley Lake during 1992. Following diversion; these waters flowed from Walnut Creek to Big Dry Creek and subsequently to the South Platte River. The RFP contribution to total flow in the South Platte River would be approximately 0.2 percent based on South Platte River flow, as measured at the Henderson, Colorado, gaging station during water year 1992 (October 1991 - September 1992) (UG93).

Municipal water supplies near RFP do not serve residences nearest the plant. For these residences, drinking water is likely from well water or bottled water sources. Currently, it is believed that no offsite drinking water wells have been contaminated with radioactive materials as a result of RFP activities. Extensive characterization of background radioactivity concentrations in groundwater and the hydrogeology of RFP are in progress to verify this belief.

During 1992, plutonium concentrations in Pond C-2 averaged 2.5 x 10^{-11} µCi/ml (9.3 x 10^{-4} Bq/l). Average americium concentration was 3 x 10^{-12} µCi/ml (1.1 x 10^{-4} Bq/l). These concentrations were used as the water ingestion source term for the maximum individual dose assessment. Uranium-233, -234 average concentration in Pond C-2 was 8.8 x 10^{-10} µCi/ml (3.3 x 10^{-2} Bq/l) and the average concentration of uranium-238 in Pond C-2 was 1.4 x 10^{-9} µCi/ml (5.3 x 10^{-2} Bq/l). The average concentrations of uranium-233, -234, and uranium-238 in incoming raw water were 3.6 x 10^{-10} µCi/ml (1.3 x 10^{-2} Bq/l) and 3.1 x 10^{-10} µCi/ml (1.1 x 10^{-2} Bq/l), respectively. The source terms used for uranium ingestion were the difference between the Pond C-2 and raw water concentrations for each of the two uranium isotope categories: 5.2 x 10^{-10} µCi/ml (1.9 x 10^{-2} Bq/l) for uranium-233, -234, and 1.1 x 10^{-9} µCi/ml (4.1 x 10^{-2} Bq/l) for uranium-238. The average tritium concentration in Pond C-2 was less than zero, reflecting the statistical variation that can occur when measuring near-zero concentrations of radioactive materials. (See Appendix D for further explanation of negative values.) Tritium is a relatively insignificant contributor to dose

at low concentrations because the radiation it emits is a very low energy beta radiation that has a relatively small dose conversion factor.

A potential exposure pathway added to the RFP radiation dose assessment in 1991 is direct ingestion of contaminated soil. Inclusion of this pathway is consistent with approaches to risk assessment suggested by the EPA in *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (EPA89b). An intake rate of 100 mg/day is assumed for this pathway. The plutonium-239, -240 in soil concentration from onsite sampling location 2-126 was taken as conservatively representative of soil for residences nearest RFP. Americium-241 was calculated to be 20 percent of the plutonium-239, -240 concentration, based on maximum ingrowth of americium-241 from plutonium-241 in typical RFP weapons-grade plutonium (DOE80). The 1992 measured plutonium-239, -240 concentration in soil at the 2-126 location is 0.27 pCi/g (1.0×10^{-2} Bq/g) (see Figure 3.5-1 and Table 3.5-1 in Section 3.5, "Soil Monitoring.") The calculated americium-241 concentration is 0.05 pCi/g (2.0×10^{-3} Bq/g).

Ground-plane irradiation by external penetrating radiation from contaminated soil areas is included as a potential pathway of exposure, although it is a relatively small contributor to dose. External penetrating radiation associated with radioactive materials of importance at RFP is generally of low energy and intensity. The ground-plane irradiation source term used for this assessment is again based on the plutonium concentration in soil measured at the onsite 2-126 location and an assumed soil density of 1 gram per cubic centimeter (g/cm^3), and a sampling depth of 5 cm used to determine areal concentration. The plutonium-239, -240 areal source term is 1.4×10^{-2} $\mu Ci/m^2$ (5.0×10^2 Bq/m^2). The americium source term is estimated at 2.7×10^{-3} $\mu Ci/m^2$ (1.0×10^2 Bq/m^2).

Table 6-3 summarizes the radionuclide concentrations used for calculating the estimate of maximum radiation dose to an individual member of the public from all the identified potential pathways of exposure. From these concentrations and dose conversion factors given in Table 6-2, a 50-year dose commitment of 4.6×10^{-1} mrem (4.6×10^{-3} mSv) is calculated as the EDE from all pathways. The bone surfaces receive the highest calculated individual organ dose, 7.6 mrem (7.6×10^{-2} mSv)

(Table 6-4). The DOE radiation protection standard for members of the public for all pathways and for prolonged periods of exposure is 100 mrem/yr (1 mSv/yr) EDE. The maximum site boundary dose in 1992 represents 0.46 percent of the standard for all pathways for EDE. This is in accordance with the DOE objective expressed in DOE Order 5400.5 that potential exposures to members of the public be as low as reasonably achievable (ALARA).

Table 6-3

Radioactivity Concentrations Used in Maximum Site Boundary Dose Calculations for All Pathways for 1992

Air (μCi/ml)	Soil (pCi/g)		Surface Deposition (μCi/m²)		Water (μCi/ml)			
Pu-239,-240	Pu-239,-240	Am-241	Pu-239,-240	Am-241	Pu-239,-240	Am-241	U-233/-234	U-238
1.6×10^{-18}	2.7×10^{-1}	5.4×10^{-2}	1.4×10^{-2}	2.7×10^{-3}	2.5×10^{-11}	3.0×10^{-12}	5.2×10^{-10}	1.1×10^{-9}

Table 6-4

50-Year Committed Dose Equivalent from 1 Year of Chronic Intake/Exposure from the RFP in 1992

Location	Effective Dose Equivalent (mrem)	Liver (mrem)	Bone Surfaces (mrem)	Lung (mrem)
Maximum Site Boundary	4.6×10^{-1}	6.2×10^{-1}	7.6	2.3×10^{-2}

Radiation Dose from Air Pathway Only

EPA-approved methodology (EPA89a) is used to demonstrate compliance with CAA NESHAP standards for airborne radioactivity emissions. As of December 15, 1989, the EPA-approved standard is based on meteorological/dose modeling of air emissions using the AIRDOS or CAP88 computer codes. Table 6-5 lists the 1992 radioactivity air emissions used as input to the CAP88-PC computer code. These emissions include building air effluent release values for the year as discussed in Section 3.2 and an estimate of resuspension of contaminated soil from RFP OUs.

Table 6-5

Radionuclide Air Emissions for Input to CAP88-PC Computer Code 1992

Radionuclide(s)	Air Emission Activity (Ci)
Building Emissions:	
H-3 (Tritium)	8.68×10^{-2}
Pu-238	1.73×10^{-8}
Pu-239, -240	3.84×10^{-7}
U-233, -234	3.38×10^{-7}
U-238	6.00×10^{-7}
Am-241	2.46×10^{-7}
Estimated Soil Resuspension:	
Pu-241	1.7×10^{-4}
Pu-239, -240	3.4×10^{-5}
Am-241	6.8×10^{-6}
Pu-238	7.9×10^{-7}

The RFP annual site environmental reports for 1989 and 1990 included an estimate of 903 Pad area (OU 2) soil resuspension that was developed in the RFP EIS, published in 1980 (DOE80). More recent field studies completed by RFP indicate that the EIS-estimated soil resuspension rate is likely to be considerably higher than is actually occurring, leading to a greatly conservative overestimate of radiation dose to the public using the EIS values. The 903 Pad area soil resuspension source term used in the 1992 radiation dose assessment was based on the more recent RFP field studies and is considered a more realistic estimate of resuspension (LA91).

For 1992, estimates of soil resuspension were expanded to include OUs 1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14, in addition to the 903 Pad area (OU 2). The resuspension rate, developed from the 903 Pad area field studies, was used for the added OUs. These other OUs have lesser soil contamination levels, and soil concentration data for them is much more limited than for the 903 Pad area. The estimates of resuspended contamination should only be considered preliminary and will be further refined as RFP site characterization is completed.

Meteorological input data for 1992, which was reformatted as required for input to the CAP88-PC calculations, is given in Tables C1 through C7, Appendix C.

CAP88-PC default values for lung clearance class and gastrointestinal uptake fractions were used when running the code. The CAP88-PC default assumption of a 1-μm activity median aerodynamic diameter (AMAD) particle size also was used.

The CAP88-PC computer code calculated an EDE from building air emissions of 2.8×10^{-5} mrem (2.8×10^{-7} mSv) to the maximally exposed individual residing approximately 2.45 miles from the plant emissions points. The EDE from estimated soil resuspension was calculated as 1.6×10^{-3} mrem (1.6×10^{-5} mSv) to the maximally exposed individual residing approximately 2.1 miles from the 903 Pad area.

Collective Population Dose

DOE Order 5400.5, promulgated February 8, 1990, requires the assessment of collective population radiation dose to a distance of 80 kilometers (50 miles) from the center of a DOE facility (DOE90a). The assessment of maximum community dose (i.e., maximum dose to an individual in a neighboring community) that was presented in RFP annual site reports prior to 1990 is no longer included in the DOE approach to radiation dose assessment.

Collective population dose is calculated as the average radiation dose to an individual in a specified area, multiplied by the number of individuals in that area. In assessing the 1992 collective population dose to the public within a radius of 50 miles of RFP, the assessment was limited to airborne emissions of radioactive materials from the plant as the major contributor to population dose. Only two public raw water supplies, Great Western Reservoir and Standley Lake, can receive water directly from drainages crossing RFP, and all surface-water effluent from RFP was diverted around these water supplies during 1992. Soil contamination decreases rapidly with distance from the RFP. In addition, most residential areas within this radius are likely to have new topsoil, sod, or otherwise modified soil conditions; agricultural areas represent a relatively small population.

Population estimates provided by the Denver Regional Council of Governments (DRCOG), the State of Colorado, and some local municipalities near RFP were used to determine the 1992 population residing within 50 miles of RFP. An area defined by a circle of

50-mile radius around the center of RFP was further divided into 16 equal sectors, with segments formed by the intersection of the sectors and a total of 10 radial distances of 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles (see Figure 6-1). The population within each segment for 1992 was based on 1990 U. S. census data and growth projections furnished by DRCOG, the State of Colorado, and local municipalities. In addition, for segments within a 10-mile radius, segment populations were determined using the *1989 Population, Economic, and Land Use Database for Rocky Flats Plant* (DOE90b) to modify population distributions. This was necessary because even the census tract data of DRCOG lacked the necessary spatial resolution of reasonable segment population estimates at distances near to RFP. Aerial photographs taken in October 1992 were used to verify the reasonableness of the population estimates for distances from 0 to 5 miles based on housing distribution as seen in these photographs.

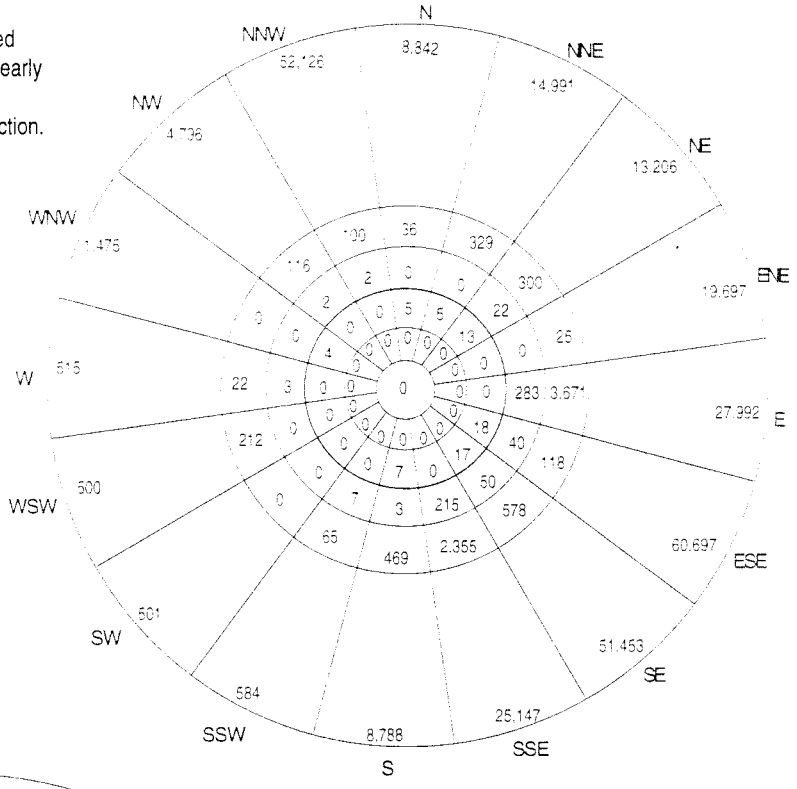
The estimates of 1992 segment populations are given in Figure 6-1. Because the census-based estimates are for political jurisdictions that do not correspond to the geographical boundaries of the segments, the population estimates of Figure 6-1 should be considered approximations only. Total population for the area within a radius of 50 miles for 1992 was estimated at 2.1 million people.

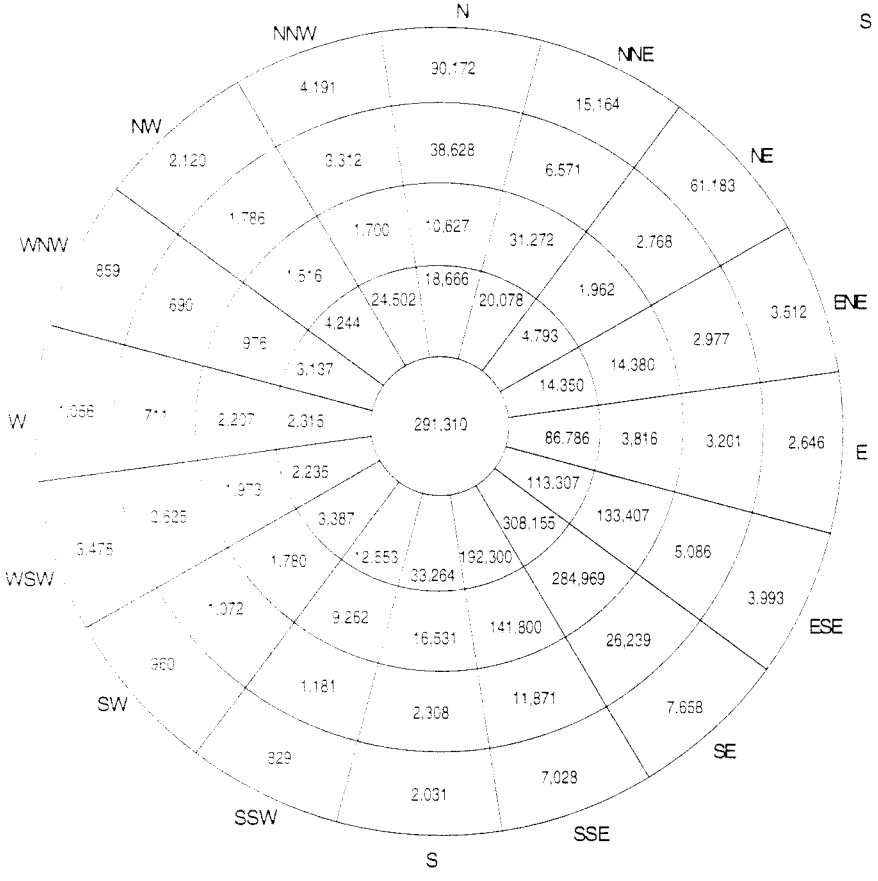
The EPA atmospheric dispersion/radiation dose calculation computer code CAP88-PC was used to calculate the collective population dose within 50 miles of RFP. CAP88-PC is the same computer code that is used by RFP to demonstrate compliance with CAA NESHAP requirements, as promulgated at 40 CFR 61, Subpart H (EPA89a). Meteorological data that were collected for RFP during 1992, population estimates as discussed above, and building air effluent radioactivity data and estimates of soil resuspension radioactivity were used as input to the CAP88-PC code. EDEs were calculated by CAP88-PC to the midpoint of each segment's radial distance. These EDEs were used as estimates of the average radiation dose to an individual residing within the segment.

Multiplying the population (number of persons) within a segment by the average individual dose (in rem or sieverts, 1 Sv = 100 rem) within the segment results in a calculated collective population dose for each segment in units of person-rem (or person-Sv). The total

These population estimates were calculated from 1990 census tract data adjusted for yearly change through 1992, assuming uniform population distribution throughout each section.

Concentric circles represent 1- to 2-, 2- to 3-, 3- to 4-, 4- to 5-, and 5- to 10-mile bands.





Concentric circles represent 10- to 20-, 20- to 30-, 30- to 40-, 40- to 50-mile bands.

Figure 6-1. 1992 Demographic Estimates for Areas 0 - 10 and 10 - 50 Miles from the RFP

person-rem for all segments is the collective population dose for a distance of 50 miles around RFP, as presented in Table 6-6 for 1992. The collective population dose within 50 miles of RFP was calculated using the code CAP88-PC as 0.1 person-rem (0.1×10^{-2} person-Sv). Significantly, the majority of this collective population dose results from estimated contaminated soil resuspension from the OUs of RFP. A very small contribution (4.0×10^{-3} person-rem [4.0×10^{-5} person-Sv]) is attributable to building air emissions for 1992.

Natural Background Radiation Dose

EDEs from RFP may be compared to an average annual EDE for the Denver area of about 350 mrem (3.5 mSv) from natural background radiation (NA87b) (Table 6-7). Natural background radiation for Denver is higher than shown for the total body in RFP annual reports prior to 1985 and also higher than shown for EDE in the 1985 and 1986 annual reports. The level reflects the most recent assessment of natural background radiation exposure of the population of the United States by the NCRP. It includes the significant contribution to EDE from inhaled indoor radon, as well as the adoption of the ICRP 30 methodology of radiation dosimetry. Cosmic radiation and external primordial nuclides sources shown in Table 6-7 reflect the regional dose levels for the Denver area from the higher elevation and greater concentration of naturally occurring uranium and thorium in soil. The internal primordial nuclides source includes the average dose from indoor radon estimated by the NCRP for the entire United States. Investigations are now being conducted to determine whether any regional differences in indoor radon doses exist. Once these studies are completed and published, the estimates of natural background radiation dose for the Denver area may be modified to reflect indoor radon doses specific to this region. It is likely that estimates of the total radiation dose from naturally occurring radiation in the Denver area will increase as a result of these studies. Indoor radon concentrations appear to be higher in the Denver area than the national average, based on preliminary study results.

Table 6-6

1992 Calculated Radiation Dose to the Public from 1 Year of Chronic Intake/Exposure from the RFP

MAXIMUM INDIVIDUAL DOSE:	
All Pathways[a]	4.6×10^{-1} mrem (4.6×10^{-3} mSv) Effective Dose Equivalent (EDE)
Building air emissions[b]	2.8×10^{-5} mrem (2.8×10^{-7} mSv) EDE
Estimated soil resuspension[c]	1.6×10^{-3} mrem (1.6×10^{-5} mSv) EDE
COLLECTIVE POPULATION DOSE TO 80 km (50 mi):	
Building air emissions[b]	4×10^{-3} person-rem (4×10^{-5} person-Sv) EDE
Estimated soil resuspension[c]	0.1 person-rem (0.1×10^{-2} person-Sv) EDE
Total	0.1 person-rem (0.1×10^{-2} person-Sv) EDE
ESTIMATED TOTAL POPULATION WITHIN 80 km (50 mi):[d]	2.1×10^{6} persons
DOE RADIATION PROTECTION STANDARDS FOR THE PUBLIC:[e]	
All Pathways[f]	100 mrem (1 mSv) EDE, normal operations 500 mrem (5 mSv) EDE, temporary increase (only with prior approval of DOE EH-2)
Air Pathway only[g]	10 mrem (1×10^{-1} mSv) EDE
ESTIMATED ANNUAL NATURAL BACKGROUND INDIVIDUAL RADIATION DOSE FOR THE DENVER METROPOLITAN AREA: [h]	350 mrem (3.5 mSv) EDE
ESTIMATED ANNUAL NATURAL BACKGROUND COLLECTIVE POPULATION DOSE WITHIN 80 km (50 mi):	7.0×10^{5} person-rem (7.0×10^{3} person-Sv) EDE

a. Calculated using environmental monitoring input data.
b. Calculated using CAP88-PC modeling of estimated and measured building air emissions.
c. Calculated using CAP88-PC modeling of estimated soil resuspension from RFP OUs 1-12.
d Based on estimates from information provided by the State of Colorado, the Denver Regional Council of Governments, and local municipalities.
e. From DOE Order 5400.5. Excludes medical sources, consumer products, residual fallout from past nuclear accidents and weapons tests, and naturally occurring radiation sources (DOE90a).
f. Based on recommendations of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).
g. Based on EPA Clean Air Act National Emission Standards for Hazardous Air Pollutants.
h. See Table 6-7 for further explanation of natural background radiation dose in the Denver Metropolitan area.

Note: In addition to the numerical dose standards listed above, it is the objective of DOE to maintain potential exposures to members of the public to ALARA levels.

Table 6-7

Estimated Annual Natural Background Radiation Dose for the Denver Metropolitan Area (NA87b)

Source	Effective Dose Equivalent (mrem)
Cosmic Radiation[a]	50
Cosmogenic Nuclides	1
Primordial Nuclides - External[b]	63
Primordial Nuclides - Internal[c]	239
Total for 1 Year (rounded)	353

a. Includes regional increase over U.S. average as a result of the greater elevation of the Denver area.
b. Includes regional increase over U.S. average as a result of the higher concentrations of uranium and thorium in soil in the Denver area.
c. Includes U.S. average indoor radon dose contribution. This value likely will increase when regional indoor radon differences for the Denver area are determined.

7. Quality Assurance and Quality Control

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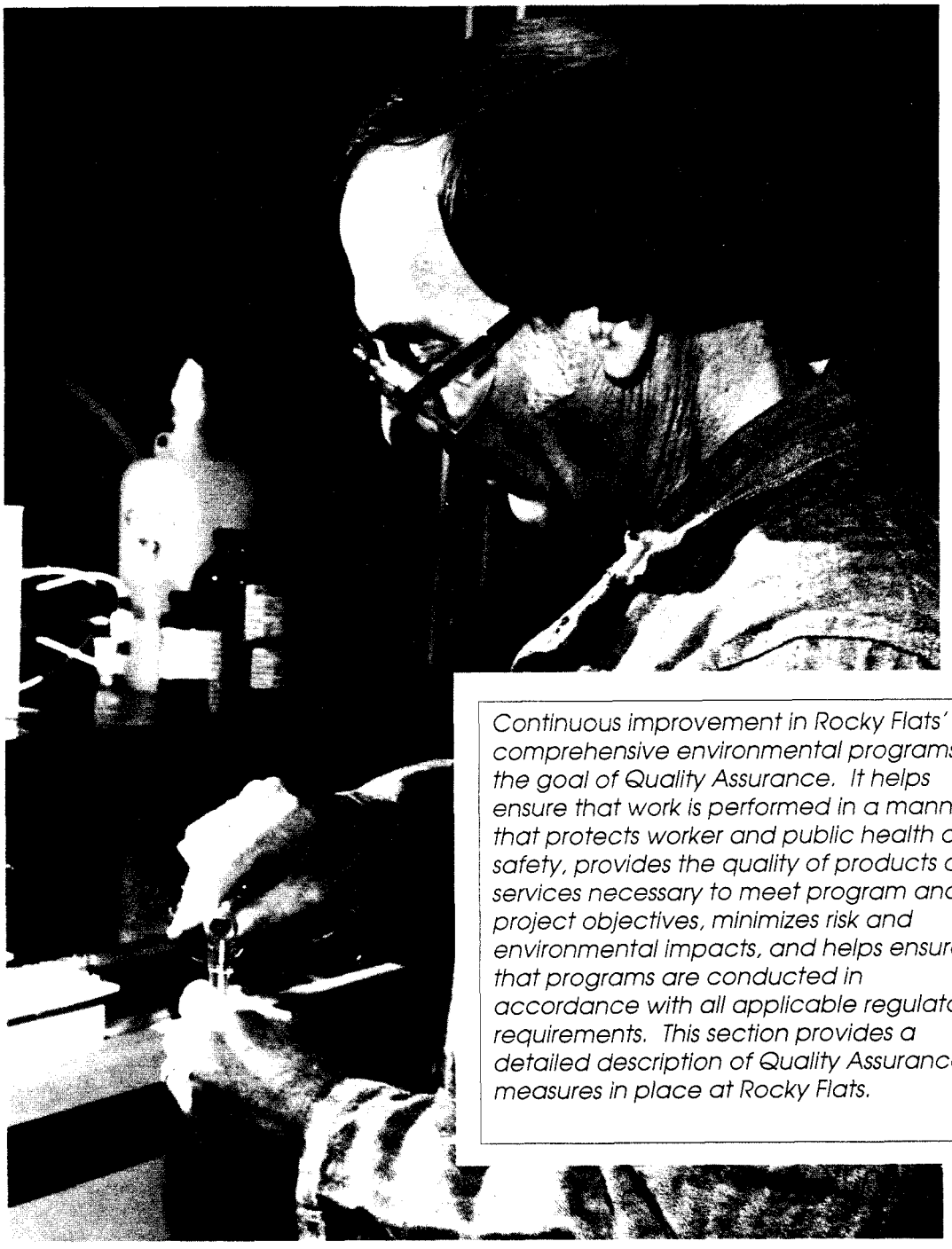

Continuous improvement in Rocky Flats' comprehensive environmental programs is the goal of Quality Assurance. It helps ensure that work is performed in a manner that protects worker and public health and safety, provides the quality of products and services necessary to meet program and project objectives, minimizes risk and environmental impacts, and helps ensure that programs are conducted in accordance with all applicable regulatory requirements. This section provides a detailed description of Quality Assurance measures in place at Rocky Flats.

OVERVIEW

In October 1992, the Environmental Management (EM) Department was reorganized to separate environmental restoration and environmental monitoring functions into two organizational units. Environmental Restoration Management (ERM) became responsible for restoration activities, while Environmental Protection Management (EPM) maintained responsibility for various environmental monitoring and permitting activities performed at RFP. As a result of the reorganization, it became necessary to revise the upper level Environmental Quality Assurance (QA) documents to clearly define the scope of work and the division of responsibilities. Those revisions are currently in progress.

Fundamentally, the Quality Assurance Plan Description (QAPD) (EG92c) is used as the foundation QA document for EPM activities. A revision to the QAPD and associated support procedures to more accurately reflect the new organizational structure is tentatively scheduled for completion in late 1993. The RFP Sitewide Quality Assurance Project Plan (QAPjP) (EG91b), a flowdown from the site Quality Assurance manual (QAM), will be used to set requirements for ERM activities. The QAPjP is targeted for revision by late summer of 1993. The revision to the QAPjP and the QAPD will incorporate the requirements of DOE Order 5700.6C *Quality Assurance*, which supersedes DOE Order 5700.6B.

The discussion in this section concerning the QA process for environmental activities encompasses the program as it existed through October 1992 and the transition period following the reorganization within the EM Department.

QUALITY ASSURANCE REQUIREMENTS

QA requirements established by the DOE, RFP, CDH, and EPA apply to both EPM and ERM activities. DOE Order 5400.1, *General Environmental Protection Program*, establishes QA requirements that apply to all DOE environmental monitoring and surveillance programs. The QAM consists of 22 quality requirements that are potentially applicable to all RFP programs, including environmental restoration and monitoring programs.

Both DOE Order 5400.1 and the QAM reference QA requirements of DOE Order 5700.6B, *Quality Assurance*. DOE Order 5700.6B endorses the 18 QA criteria and supplemental requirements of the *American Society of Mechanical Engineers NQA-1, Quality Assurance for Nuclear Facilities* (ASME89). The RFP IAG requires DOE to prepare and implement a QA Project Plan for the ER program activities specified in the IAG, which incorporates the 16 quality elements of EPA's *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA80).

RFP received notification from DOE on December 31, 1991, to begin implementation of DOE Order 5700.6C, which facilitates the approach for empowerment of line management to achieve and maintain quality, as opposed to the approach used in DOE Order 5700.6B. The QAM is currently being revised because of the implementation of DOE Order 5700.6C, and because of the responsibility changes that resulted from the October 1992 reorganization. The revision, expected to be completed in mid-1993, will incorporate all pertinent environmental requirements as well as the 10 QA criteria and other concepts associated with DOE Order 5700.6C.

QA PROGRAM

The EM Department initiated development of its QA process for its environmental activities in 1990. The EM QA process identified QA requirements that applied to EM programs and projects and established methods, controls, and responsibilities for meeting those requirements. The EM QA process integrated quality requirements established by DOE, RFP, and the EPA.

The EM QA process consisted of (1) the QAPD, (2) the RFP Sitewide QAPjP for CERCLA Remedial Investigations/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities, and (3) EM Administrative and Operating Procedures. The requirements, methods, controls, and responsibilities established in the QAPD apply to all EM programs and projects, whereas those established in the QAPjP apply only to RFP ER program activities that are required by the IAG. (The QAPjP was prepared in addition to the QAPD because it was specified as a deliverable document in the IAG.) The administrative

procedures provide administrative controls and direction for the performance of a program, project, or activity, while the operating procedures provide controls and direction for performance of routine operations and for the collection and analysis of environmental samples. These procedures are developed to implement environmental protection and restoration programs and are submitted to the EPA and CDH for review and approval in accordance with requirements of the IAG.

The QAPjP was approved by the EPA and CDH in June 1991. Based on review by the EG&G Rocky Flats QA Organization, the first draft of the QAPD was revised significantly during 1991. The revised QAPD was approved on January 23, 1992.

The QAPjP is supplemented by QA Addenda (QAA) that are prepared for each ER program work plan. QAA specify any additional quality requirements, quality controls, and methods that are specific to the work activities addressed by the respective work plan. QAA also address project-specific data quality objectives and reference applicable operating procedures.

Quality Assurance Implementation Verification

Implementation of QA Program requirements, controls, and methods is verified by conducting internal readiness reviews, surveillances, and inspections of environmental program and project work activities. Internal QA verification activities are performed by personnel who are independent of the work activities being conducted. The EG&G Rocky Flats QA Organization also conducts independent assessments of environmental programs and projects. A change is planned in 1993 when the ERM Quality process will shift to a self-evaluation concept from an oversight concept, more efficiently incorporating quality at the floor level.

During 1992, approximately 82 internal inspections of environmental activities were conducted. The activities of various subcontractors were inspected to ensure that activities were performed in compliance with the requirements and specifications of the QAPjP, QAA, work plans, and operating procedures. Inspections consist of observations of the activities being conducted and examination of the records generated by the activity. These oversight inspections are performed in

the field at sampling and test sites, at the main decontamination facility, and at the subcontractors' field trailers. Following is a list of activities that were inspected.

- Collecting geotechnical, hydrologic, and ecological environmental samples
- Augering, drilling, and coring
- Trenching
- Logging and handling geotechnical materials
- Handling, labeling, containerizing, preserving, and shipping samples
- Tracking samples (sample chain-of-custody)
- Installing monitoring wells and piezometers
- Field surveys
- Field analysis and generating field measurement data
- Radiological screening of environmental samples
- Documenting samples
- Decontaminating general and heavy equipment
- Collecting and/or preparing quality control sample blanks
- Calibrating instruments and recording calibration
- Storing samples
- Using and maintaining current work plans, procedures, and forms
- Record-keeping and data management

Inspection checklists were used to conduct the inspections, and the results of each inspection were documented on an inspection report.

In 1992, seven readiness reviews were conducted on ERM activities. Readiness reviews are conducted to determine whether a planned project or work activity is ready to proceed. Readiness reviews are performed under the direction of the ERM Quality Assurance Program Manager (QAPM), who selects a readiness review team and a review team leader. The leader prepares a readiness review checklist, which consists of applicable work activity prerequisites, requirements, and other pertinent information that provides evidence for determining readiness. The checklist is then used to document the readiness to proceed with the project or work activity.

Readiness reviews were conducted before the following projects began.

- Operable Unit 1 (881 Hillside) Treatability Study Field Sampling Plan
- Operation and Maintenance of the 881 Hillside Interim Measures/Interim Remedial Action
- Operable Unit 3 (Offsite Area) RCRA Facility Investigation/Remedial Investigation
- Operable Unit 4 (Solar Evaporation Ponds) RCRA Facility Investigation/Remedial Investigation
- Operable Unit 5 (Woman Creek) RCRA Facility Investigation/Remedial Investigation
- Operable Unit 6 (Walnut Creek) RCRA Facility Investigation/Remedial Investigation
- Operable Unit 7 (Present Landfill) RCRA Facility Investigation/Remedial Investigation

After the projects are initiated, internal surveillance is performed for each project under the direction of the ERM QAPM. In addition to surveillance of the above projects, surveillance also was conducted for the following.

- Drill Cutting Drum Management and Characterization
- Operation and Maintenance of the OU 1 IM/IRA
- Data Traceability Surveillance

These surveillances consist of observing project work activities to verify that they are being conducted according to the QA requirements specified in the QAPjP, QAA (as appropriate), and project work plans. The result of each surveillance is documented in a report prepared by the surveillance team leader. The surveillance report documents observations, deficiencies, and recommendations.

The EG&G Rocky Flats QA Organization conducted an independent audit of the environmental QA process in October 1992 to verify that the program complies with RFP requirements. In addition, DOE RFO also conducted an audit of environmental QA in December 1992.

ANALYTICAL LABORATORIES

Environmental analyses are performed at RFP by the Analytical Laboratories, which are made up of subordinate laboratories. These include the Environmental Radiochemistry Laboratory located in Building 123 and the General Organic, General Inorganic, and

General Radiochemistry Laboratories, which comprise the General Laboratories located in Building 881.

The Analytical Laboratories Quality Assurance Plan provides comprehensive guidance to ensure the quality of environmental data. This plan includes a description of the laboratory organization, functions, responsibilities, policies, and programs that comprise the overall QA program. Highlights of the program are provided below.

- Staff qualification and training
- Analytical procedure development, control, and compliance
- Laboratory records and sample handling protocols
- Analytical instrument calibration, control, and maintenance
- Reagent purity and standardization
- Measurement control (intralaboratory and interlaboratory programs) and data review
- Self-appraisals and corrective actions

Detailed quality control for the reliability of analytical data is provided in each analytical operating procedure. Typically, samples are analyzed in daily batches containing approximately 25 percent control samples. Control samples consist of various blanks, duplicates, standards, and spikes. This batching of samples and controls ensures reproducible, quality measurements. Traceable standards are prepared both within and independently of the laboratory. Statistical evaluation in the form of precision and accuracy of the control samples determines the acceptability of the sample batch data relative to the data quality specifications agreed upon with the customer. If any samples require reanalysis, those samples are included in another Quality Control (QC) batch.

Any unusual condition that may affect the results, observed during sample collection, analysis, or QA review, is reported to appropriate management officials. QA provides written notification to management to suspend the analytical operation, pending review and corrective actions, when process control charts or other statistical evaluations indicate that the process is not in control (out of control).

The Analytical Laboratories participate in a number of independent blind sample programs to control and assess analytical measurements. More than 275 blind

samples are submitted monthly to the Laboratory for the RFP Interactive Measurement Evaluation and Control System. This program provides feedback on analyses as well as monthly reports and meetings to review analytical results. Performance samples from the EPA for the NPDES program are analyzed and evaluated annually. Environmental samples from the United States Geological Survey (USGS) are evaluated biannually. The Laboratory participates in radiochemistry programs conducted by the EPA Environmental Monitoring Systems Laboratory and the DOE Environmental Measurements Laboratory (EML). The General Laboratory also purchases (from an independent commercial laboratory) a suite of water samples for a quarterly program administered by the laboratory QA officer.

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9. Useful Information

ABBREVIATIONS

Units of Measure

Bq	Becquerel
Bq/l	Becquerel per liter
Bq/m^2	Becquerel per square meter
Bq/m^3	Becquerel per cubic meter
°C	Degree Celsius
Ci	Curie
Ci/g	Curie per gram
cm	Centimeter
cm^3	Cubic centimeter
d/m/μCi	Disintegration per minute per microcurie
d/m/pCi	Disintegration per minute per picocurie
d/m/f	Disintegration per minute per filter
d/m/l	Disintegration per minute per liter
dpm/g	Disintegration per minute per gram
dps	Disintegration per second
°F	Degree Fahrenheit
ft^2	Square Foot
ft^3/min	Cubic foot per minute
fpm	Foot per mile
g	Gram
gal	Gallon
g/cm^2	Gram per square centimeter
g/day	Gram per day
gpm	Gallon per minute
ha	Hectare
kg	Kilogram
km	Kilometer
l	Liter
l/d	Liter per disintegration
l/s	Liter per second
lb	Pound
m^2	Square meter
m^3	Cubic meter
m^3/s	Cubic meter per second
mg/cm^2	Milligram per square centimeter
mg/l	Milligram per liter
ml	Milliliter
ml/day	Milliliter per day
ml/s	Milliliter per second
mph	Mile per hour
mrem	Millirem
mrem/day	Millirem per day
mrem/yr	Millirem per year
m/s	Meter per second
m^3/s	Cubic meter per second

mSv	Millisievert
mSv/yr	Millisievert per year
µCi	Microcurie
$\mu Ci/m^2$	Microcurie per square meter
µCi/ml	Microcurie per milliliter
µg	Microgram
µg/f	Microgram per filter
µg/l	Microgram per liter
$\mu g/m^3$	Microgram per cubic meter
µg/ml	Microgram per milliliter
pCi	Picocurie
pCi/g	Picocurie per gram
pCi/l	Picocurie per liter
ppb	Part per billion
ppm	Part per million
pt	Pint
%	Percent
rem	Roentgen equivalent man
rem/yr	Roentgen equivalent man per year
s	second
SI	International Standard
Sv	Sievert
yd^3	Cubic yard

Chemical Elements and Compounds

Am	Americium
Ba	Barium
Be	Beryllium
Ca	Calcium
CCl_4	Carbon Tetrachloride
Cl	Chlorine
Cm	Curium
CO	Carbon Monoxide
Co	Cobalt
Cr	Chromium
Cs	Cesium
Fe	Iron
H-3	Hydrogen-3 (Also called Tritium)
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Na	Sodium
NO_2	Nitrogen Dioxide
NO_3	Nitrate
O_3	Ozone
Pb	Lead
PCB	Polychlorinated Biphenyls
PCE	Tetrachloroethene
Pu	Plutonium
Ru	Ruthenium
Se	Selenium
SO_2	Sulfur Dioxide
SO_4	Sulfate
Sr	Strontium
TCA	1,1,1 - Trichloroethane
TCE	Trichloroethene
Tm	Thulium
U	Uranium
Zn	Zinc

ACRONYMS AND INITIALISMS

ACO	Administrative Compliance Order
ADM	Action Description Memorandum
AEC	Atomic Energy Commission
AIP	Agreement In Principle
ALARA	As Low As Reasonably Achievable
AMAD	Activity Median Aerodynamic Diameter
AMRRR	Annual Mixed Residue Reduction Report
ANSI	American National Standards Institute
APCD	Air Pollution Control Division
APEN	Air Pollutant Emission Notice
APR	Annual Progress Report
AQCC	Air Quality Control Commission
AQD	Air Quality Division
AR	Administrative Record
ARAR	Applicable or Relevant and Appropriate Requirement
ASME	American Society of Mechanical Engineers
BAT	Best Available Technology
BEAR	Biological Effects of Atomic Radiation
BIER	Biological Effects of Ionizing Radiation
BMP	Best Management Practices
BOD_5	Biochemical Oxygen Demand, 5-day incubation period
BRAP	Baseline Risk Assessment Plan
CAA	Clean Air Act
CAQCC	Colorado Air Quality Control Commission
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS/FS	Corrective Measures Study/Feasibility Study
COMRAD	Community Radiaiton Monitoring Program
CPDWR	Colorado Primary Drinking Water Regulations
CRP	Community Relations Plan
CT&CS	Chemical Tracking and Control System
CTMP	Comprehensive Treatment and Management Plan
CWA	Clean Water Act
CWQCC	Colorado Water Quality Control Commission
CX	Categorical Exclusion
CY	Calendar Year
DAR	Duct Assessment Report
DCG	Derived Concentration Guide
D&D	Decontamination and Decommissioning
DMR	Discharge Monitoring Report
DOE	Department of Energy
DOE-HQ	Department of Energy Headquarters

DRCOG	Denver Regional Council of Governments
EA	Environmental Assessment
EC	Environmental Checklist
ECF	Element Correction Factors
EcMP	Ecological Monitoring Program
EDE	Effective Dose Equivalent
EE	Environmental Evaluation
EIS	Environmental Impact Statement
EM	Environmental Management
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPM	Environmental Protection Management
ER	Environmental Remediation
ERDA	Energy Research and Development Administration
ERM	Environmental Restoration Management
ERWM	Environmental Restoration and Waste Management
ESE	Environmental Science and Engineering
FBI	Federal Bureau of Investigation
FFCA	Federal Facilities Compliance Agreement
FIDLER	Field Instrument for the Detection of Low-Energy Radiation
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FS	Feasibility Study
FSP	Field Sampling Plan
FY	Fiscal Year
FYP	Five-Year Plan
GAC	Granular Activated Carbon
GAO	General Accounting Office
GI	Gastrointestinal
H&S	Health and Safety
HEPA	High Efficiency Particulate Air
HHRA	Human Health Risk Assessment
HPGe	High Purity Germanium
HSWA	Hazardous and Solid Waste Amendments
HQ	Headquarters
IAG	Inter-Agency Agreement
ICP	Inductively Coupled Plasma
ICP-MS	Inductively Coupled Plasma Mass Spectrometer
ICRP	International Commission on Radiological Protection
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measures/Interim Remedial Action
IRA	Interim Remedial Action
IRAP	Interim Remedial Action Plan
LDR	Land Disposal Restrictions
LEPC	Local Emergency Planning Committee
LLW	Low-level Waste
MAP	Mitigation Action Plan
MDA	Minimum Detectable Amount

MDL	Minimum Detection Limit
MRRR	Mixed Residue Reduction Report
MSDS	Material Safety Data Sheet
NAAQS	National Ambient Air Quality Standards
NCC	NEPA Compliance Committee
NCRP	National Council on Radiation Protection and Measurements
NDA	Non-Destructive Assay
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NOI	Notice of Intent
NOID	Notice of Intent to Deny
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NQA1	Nuclear Quality Assurance
NRC	Nuclear Regulatory Commission; National Response Center
NTS	Nevada Test Site
ODS	Ozone-Depleting Substances
OPWL	Original Process Waste Lines
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Act
OU	Operable Unit
PA	Protected Area
PEIS	Programmatic Environmental Impact Statement
PM-10	Particulate Matter less than 10 micrometers in diameter
PPCD	Plan for Prevention of Contaminant Dispersion
PRMP EIS	Plutonium Recovery Modification Project Environmental Impact Statement
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAMS	Quality Assurance Management Staff
QAPD	Quality Assurance Program Description
QAPjP	Quality Assurance Project Plan
QAPM	Quality Assurance Program Manager
QAPP	Quality Assurance Program Plan
QAR	Quality Assurance Requirements
QC	Quality Control
RACT	Reasonable Available Control Technology
RCRA	Resource Conservation and Recovery Act
RDLWP	Radionuclides Discharge Limits Work Plan
RFI/RI	RCRA Facility Investigations/Remedial Investigations
RFO	Rocky Flats Office
RFP	Rocky Flats Plant
RFQAM	Rocky Flats Quality Assurance Manual
RHL	Radiological Health Laboratories
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPP	Resource Protection Program

RS	Responsiveness Summary
SAAM	Selective Alpha Air Monitor
SAR	Safety Analysis Report
SARA	Superfund Amendment and Reauthorization Act
SARF	Supercompactor and Repackaging Facility
SDWA	Safe Drinking Water Act
SERC	State Emergency Response Commission
SI	International Standard
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC/BMP	Spill Prevention Control and Countermeasures/Best Management Practices
SSP	Site-Specific Plan
STP	Sewage Treatment Plant
SU	Standard Units
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solid
TLD	Thermoluminescent Dosimeter
TRG	Technical Review Group
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSP	Total Suspended Particulates
TSWP	Treatability Study Work Plan
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WET	Whole Effluent Toxicity
WSRIC	Waste Stream and Residue Identification and Characterization
WWTP	Waste Water Treatment Plant

GLOSSARY

activity. See radioactivity.

air pollutant. Any fume, smoke, particulate matter, vapor, gas, or combination thereof that is emitted into or otherwise enters the atmosphere, including, but not limited to, any physical, chemical, biological, radioactive (including source material, special nuclear material, and by-product materials) substance, or material, but does not include water vapor or steam condensate.

aliquot. Of, pertaining to, or designating an exact divisor or factor of a quantity, especially of an integer.

alpha particle. A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (2 protons, 2 neutrons).

atom. Smallest particle of an element capable of entering into a chemical reaction.

beta particle. A negatively charged particle emitted from the nucleus of an atom having a mass and charge equal to that of an electron.

concentration. The amount of a specified substance or amount of radioactivity in a given volume or mass.

contamination. The deposition of unwanted radioactive or hazardous material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation. Radiation of many types with very high energies, originating outside the earth's atmosphere. Cosmic radiation is one source contributing to natural background radiation.

curie (Ci). The traditional unit for measurement of radioactivity based on the rate of radioactive disintegration. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are in common usage.

millicurie (mCi). 10^{-3} Ci, one-thousandth of a curie; 3.7×10^{7} disintegrations per second.

microcurie (μCi). 10^{-6} Ci, one-millionth of a curie; 3.7×10^{4} disintegrations per second.

nanocurie (nCi). 10^{-9} Ci, one-billionth of a curie; 37 disintegrations per second.

picocurie (pCi). 10^{-12} Ci, one-trillionth of a curie; 3.7×10^{-2} disintegrations per second.

femtocurie (fCi). 10^{-15} Ci, one-quadrillionth of a curie; 3.7×10^{-5} disintegrations per second.

attocurie (aCi). 10^{-18} Ci, one-quintillionth of a curie; 3.7 x 10^{-8} disintegrations per second.

decay, radioactive. The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

Derived Concentration Guide (DCG). Secondary radioactivity in air and water concentration guides used for comparison to measured radioactivity concentrations. Calculation of DCG assumes that the exposed individual inhales 8,400 cubic meters of air per year or ingests 730 liters of water per year at the specified radioactivity DCG with a resulting radiation dose of 0.1 rem (100 mrem) EDE.

disintegration, nuclear. A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dose, absorbed. The amount of energy deposited by radiation in a given mass of material. The unit of absorbed dose is the rad or the gray (1 gray = 100 rad).

dose commitment. The total radiation dose projected to be received from an exposure to radiation or intake of radioactive material throughout the specified remaining lifetime of an individual. In theoretical calculations, this specified lifetime is usually assumed to be 50 years.

dose equivalent. A modification to absorbed dose that expresses the biological effects of all types of radiation (e.g., alpha, beta, gamma) on a common scale. The unit of dose equivalent is the rem or the sievert (1 sievert = 100 rem).

ephemeral. Lasting for a brief period of time; short-lived, transitory.

exposure. A measure of the ionization produced in air by X-ray or gamma + radiation. The special unit of exposure is the roentgen (R).

friable. Readily crumbled; brittle.

gamma ray. High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an atom. Gamma radiation frequently accompanies the emission of alpha or beta particles. Gamma rays are identical to X-rays except for the source of the emission.

half-life, radioactive. The time required for a given amount of a radionuclide to lose half of its activity by radioactive decay. Each radionuclide has a unique half-life.

isotopes. Forms of an element having the same number of protons in their nuclei and differing in the number of neutrons.

minimum detectable concentration (MDC). The smallest amount or concentration of a radioelement that can be distinguished in a sample by a given measurement system in a preselected counting time at a given confidence level.

natural radiation. Radiation arising from cosmic sources and from naturally occurring radionuclides (such as radon) present in the human environment.

outfall. The place where a storm sewer or effluent line discharges to the environment.

part per billion (ppb). Concentration unit approximately equivalent to micrograms per liter.

part per million (ppm). Concentration unit approximately equivalent to milligrams per liter.

pathway. Potential route for exposure to radioactive or hazardous materials.

person-rem. The traditional unit of collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

quality factor. The factor by which the absorbed dose (in rad or gray) is multiplied to obtain the dose equivalent (in rem or sievert). The dose equivalent is a unit that expresses on a common scale for all ionizing radiation the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad. A traditional unit of absorbed dose. The International System of Units (SI) unit of absorbed dose is the gray (1 gray = 100 rads).

radioactivity. The spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the unstable nucleus of an atom.

radionuclide. An atom having an unstable ratio of neutrons to protons so that it will tend toward stability by undergoing radioactive decay. A radioactive nuclide.

rem. The traditional unit of dose equivalent. Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem. The International System of Units (SI) unit of dose equivalent is the sievert (1 sievert = 100 rem).

roentgen (R). The traditional unit of exposure to X-ray or gamma radiation based on the ionization in air caused by the radiation. One roentgen is equal to 2.58×10^{-4} coulombs per kilogram of air. A common expression of radiation exposure is the milliRoentgen (1R = 1000 mR).

sievert (Sv). International System of Units (SI) unit for radiation dose (1 sievert = 100 rem).

thermoluminescent dosimeter (TLD). A device used to measure external sources (i.e., outside the body) of penetrating radiation such as X-rays or gamma rays.

uncontrolled area. Any area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials. The area beyond the boundary of the RFP is an uncontrolled area.

worldwide fallout. Radioactive debris from atmospheric weapons testing that is either airborne and cycling around the earth or has been deposited on the earth's surface.

Appendix A

PERSPECTIVE ON RADIATION

OVERVIEW

Activities at the RFP can involve handling radioactive materials and operating radiation-producing equipment. Environmental monitoring programs include monitoring for potential exposures to the public from RFP-related radiation sources. This section provides some basic concepts of radiation to assist in the understanding and interpretation of monitoring information and radiation dose assessment.

Further discussion on sources of ionizing radiation can be found in Report No. 93 of the *National Council on Radiation Protection and Measurements, Ionizing Radiation Exposure of the Population of the United States* (NA87a), from which much of the information in this section was derived.

IONIZING RADIATION

Many kinds of radiation exist in our environment. Visible light and heat radiating from a warm object are examples. Radiation from radioactive materials and radiation-producing equipment is called ionizing radiation. Ionizing radiation has sufficient energy to separate electrons from atoms of material. That means it can change the physical state, or chemical composition, of atoms which it strikes, causing them to become electrically charged or "ionized." In some circumstances, these ions can disrupt normal biological processes and can present a health hazard to humans. Consequently, protective measures may be required to minimize the amount of ionizing radiation to which a person might be exposed.

Types of Radiation

X-rays, gamma rays, neutrons, and alpha and beta particles are common types of ionizing radiation. While all types of ionizing radiation can produce ionization, they have other differing properties including their ability to penetrate or pass through materials. Alpha radiation penetrates poorly; a piece of paper or the outer skin tissue on a human body can stop it. Beta radiation has low to moderate penetrating ability and can be stopped by a thin sheet of aluminum or thick plastic. Gamma, x-ray, and neutron radiation usually have much greater penetrating ability and require more extensive shielding. Radiation produced by medical x-ray machines, for example, is able to pass through a human body.

At RFP, the principal radiation hazard to the public associated with the radioactive materials handled at the plant is from alpha radiation. Alpha radiation is emitted by artificially produced radioactive materials such as plutonium and americium, as well as by naturally occurring materials such as uranium and thorium.

Production of Radiation

Ionizing radiation is produced by both radioactive materials and by radiation-producing equipment. Radiation-producing equipment includes x-ray machines and linear accelerators. Electrical power must be applied to this equipment to produce radiation. In contrast, radioactive materials will continue to emit ionizing radiation until they have undergone radioactive decay to a nonradioactive, stable state. The time required for a material to reach this stable state depends on a material's radioactive half-life.

Half-life is the amount of time required for one-half of the atoms of a radioactive material to experience radioactive decay. Half-life is unique and unchanging for each specific radionuclide. Half-lives for different radionuclides may range from seconds to billions of years. Radioactive iodine-131, used in medical diagnosis and the treatment of some diseases, has a half-life of approximately 8 days, while naturally occurring uranium-238 has a half-life of more than 4.5 billion years. In general, the half-lives of the radioactive materials handled at RFP are long; plutonium-239 has a half-life of more than 24,000 years. As a result, the materials at RFP are handled and controlled as if they will always be radioactive.

Radiation Dose

The biological effect of ionizing radiation is called radiation dose. The radiation can be from a penetrating radiation source located outside of the body (external radiation) or from radioactive materials taken into the body (internal radiation). In the United States, radiation dose is measured in the unit called the rem, or millirem (1 rem = 1,000 millirem). The comparable International Standard (SI) unit of radiation dose is the sievert (1 Sv = 100 rem). A rem is a unit of biological dose that expresses biological damage on a common scale. The Effective Dose Equivalent (EDE) is a means of calculating radiation dose and is expressed in units of rem or sieverts. EDE takes into account the total health risk estimated for cancer mortality and serious genetic effects from radiation exposure regardless

of which body tissues receive the dose or the sources or types of ionizing radiation producing the dose. One rem EDE from naturally occurring radiation has the same total health risk as one rem from artificially-produced sources of radiation.

Principal Hazards

Scientists have been studying ionizing radiation and its effects on human health for more than 90 years. In 1981, the United States General Accounting Office (GAO) reported that there were more than 80,000 separate scientific studies on the health effects of radiation. According to the National Science Foundation, "...it is fair to say that we have more scientific evidence on the hazards of ionizing radiation than most, if not all, other environmental agents that affect the general public" (NA80).

The first case of human injury reported as a result of radiation occurred shortly after Wilhelm Roentgen's discovery of x-rays in 1895. Early radiologists often used their hands to focus the primitive fluoroscopic equipment, which exposed them to millions of millirems of radiation. The first case of radiation-induced skin cancer was reported as early as 1902. In later years, it was shown that physicians, x-ray technicians, and radium handlers had cancer rates higher than normal.

Early efforts to set radiation standards were made by the Roentgen Society formed in 1916. This was followed in 1921 by the newly created British x-ray and Radiation Protection Committee and in 1928 by the International Commission on Radiological Protection (ICRP). In 1929, the Advisory Committee on x-ray and Radium Protection was founded in the United States; this is now the National Council on Radiation Protection and Measurements (NCRP). The ICRP and the NCRP represent the longest continuous experience in the review of radiation health effects and recommendations on guidelines for radiological protection and radiation exposure limits. Additional organizations also have examined radiation levels, including the United Nations Scientific Committee on the Effects of Atomic Radiation and the National Academy of Sciences (NAS). The NAS formed a committee in 1956 to review the biological effects of atomic radiation (BEAR). A series of reports have since been issued by this and succeeding NAS committees on the

biological effects of ionizing radiation (BEIR). The NAS continues to review the health effects of ionizing radiation.

Exposure to high levels of radiation can cause serious health effects including burns, cell damage, and death. The degree of effect depends on the intensity of radiation dose, length of exposure, and type and number of body cells exposed. Sudden large doses of 100,000 to 150,000 mrem to the whole body can cause radiation sickness, with short-term symptoms including nausea, fatigue, and hair loss. A sudden dose of 500,000 to 600,000 mrem can be fatal.

Among radiation scientists, there is substantial agreement on the health effects and risks following such large radiation doses. What remains in question, however, is the assessment of potential health effects that may result from very small doses of radiation over longer periods of time. Although radiation can damage living cells, this damage does not necessarily cause noticeable health effects. For some types of radiation the body can often repair damage from low doses or from doses received over long periods of time. In other situations if the radiation dose results in cell death, only a relatively few cells may be affected and there may be no detectable effect on tissue function or overall health.

Some radiation damage to cells can result in an increased risk of cancer later in life. This increased risk has been observed in populations exposed to high doses of radiation. At low doses, however, the increased risk, if it occurs, is too small to be measured against the variability that occurs in the normal cancer incidence. Although it is not known if an increase in cancer risk actually occurs at low doses, for the purpose of radiation protection, it is assumed that it does. Radiation protection standards are established assuming that any additional radiation dose carries with it some additional risk, and that the degree of risk is proportional to the dose received. At low doses, such as experienced from natural background radiation, this estimated additional risk is very small compared to the normal incidence of cancer. Nevertheless, radiation protection professionals seek to minimize any unnecessary radiation dose and to reduce radiation doses to levels that are as low as reasonably achievable (ALARA). The maximum radiation dose to the public as a result of RFP activities typically is far less than that received from natural background radiation.

SOURCES OF RADIATION

All living things are exposed to naturally occurring ionizing radiation. However, since the discovery of radiation and radioactive materials at the end of the 1800s, a person might significantly increase their amount of radiation exposure through the use of artificially produced or enhanced sources of radiation.

Natural Sources

Naturally occurring sources are the greatest contributor to radiation exposures for the population of the United States. Sources of natural background radiation include cosmic radiation from space and secondary radioactive materials (cosmogenic nuclides) created when cosmic radiation enters the earth's atmosphere. Another source is naturally occurring radioactive materials originating from the earth's crust, referred to as primordial nuclides. These materials may contribute to radiation exposure when located outside the body or when taken into the body through inhalation or ingestion. Radon, a radioactive gas derived from uranium, is an important contributor to internal radiation exposure as a result of inhalation indoors. Trace amounts of uranium and radium also can be found in drinking water, while milk contains naturally radioactive potassium.

Living in different geographical areas can result in more or less exposure to naturally occurring ionizing radiation. Cosmic radiation exposure can increase as altitude increases because less atmosphere exists to shield against the radiation. Some geographical areas have higher concentrations of primordial nuclides such as uranium and thorium. Because the Denver area is located at a relatively high altitude and also has higher concentrations of uranium and thorium in rocks and soil, naturally occurring radiation levels are higher than those in many other regions in the country.

The annual, naturally occurring EDE to a typical resident of the Denver metropolitan area is provided in Section 6. The total for this area, based on current published reports, is about 350 mrem/yr. This estimate is likely to increase as the Denver regional difference in indoor radon concentration is determined. Preliminary studies have indicated that indoor radon concentrations are higher than the national average. The estimated total average EDE for a person in the United States from natural sources including radon is about 300 mrem/yr.

Medical Sources

Ionizing radiation is successfully used in medicine for the diagnosis and treatment of many medical conditions. This radiation can be produced by equipment such as x-ray machines or linear accelerators, or it can originate from radioactive materials incorporated into pharmaceuticals. Medical diagnosis and treatment account for the largest radiation doses to the United States public from artificially produced sources of radiation. The average EDE to an individual in the United States from medical sources is approximately 50 mrem/yr. However, individual doses from this source vary widely, with some people receiving little or none and others receiving substantially more than the average in any particular year.

Consumer Products Sources

Some consumer products, including tobacco, smoke detectors, fertilizers, and television sets have ionizing radiation associated with them. Consumer products are the second largest contributor to radiation dose to the United States population from artificially produced or enhanced sources. The radiation may or may not be intentional and necessary for the product to function. Ionization smoke detectors and x-ray baggage inspection systems at airports require ionizing radiation to perform their functions. Tobacco products, fuels such as coal, and television receivers have radiation associated with them even though it is not necessary for their use.

Other Sources

Naturally occurring, medical, and consumer product sources contribute more than 99 percent of the average radiation dose that a person living in the United States receives each year (Figure A-1). Other sources include occupational exposures, residual fallout from past atmospheric weapons testing, the nuclear fuel cycle, and miscellaneous sources. Combined, these other sources contribute less than 1 percent of the average radiation dose to a person living in the United States.

RFP Contributions to Radiation Dose

The additional radiation dose that a member of the public might receive from RFP activities is typically well within applicable radiation protection limits and far below dose levels received from naturally occurring radiation sources. RFP-related EDE to the maximally exposed member of the public is typically less than 1 mrem for 1 year's chronic exposure. Section 6 discusses the assessment of radiation dose to the public for CY92.

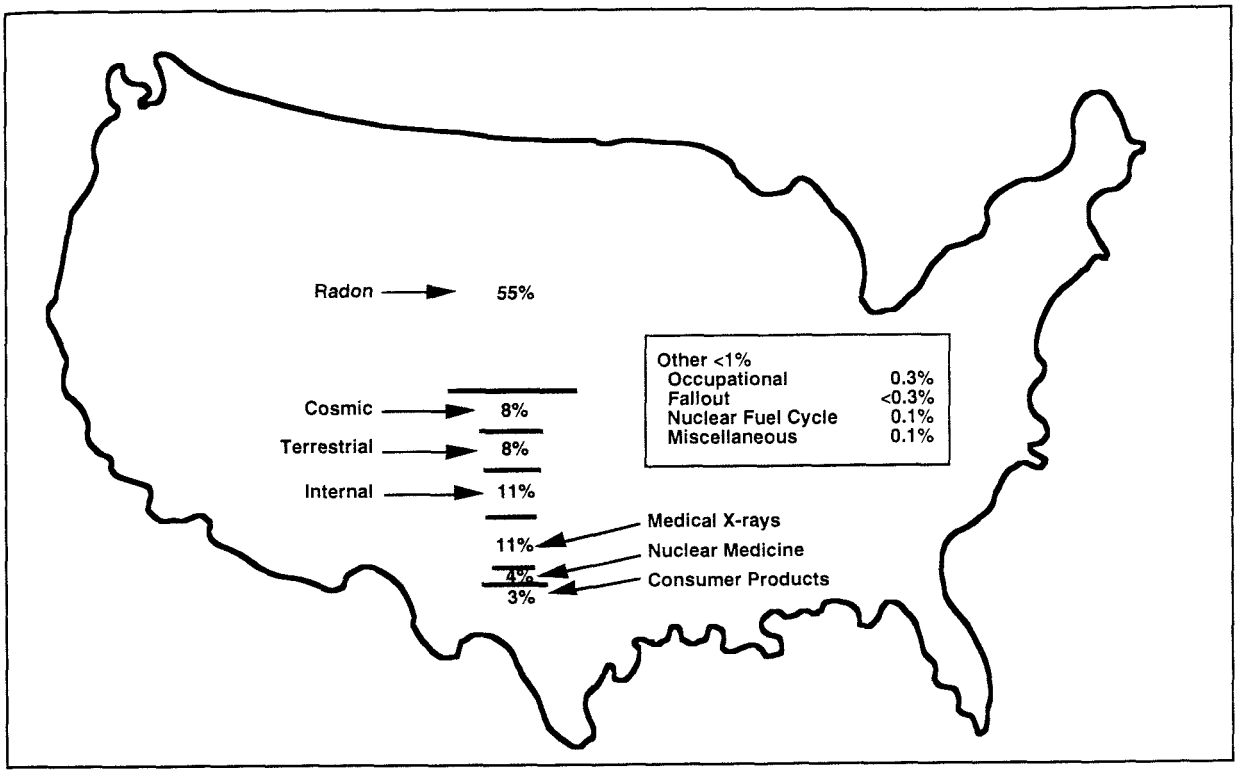

Figure A-1. Contribution of Various Sources to the Total Average Radiation Dose to the United States Population

Appendix B

APPLICABLE GUIDES AND STANDARDS

OVERVIEW

RFP environmental monitoring programs evaluate plant compliance with applicable guides, limits, and standards. Guide values and standards for radionuclides in ambient air and waterborne effluents have been adopted by the DOE, CDH, CWQCC (for water only), and the EPA (for the air pathway only) (CDH78, EPA85). Many of these guides are based on recommendations published by the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).

AIR STANDARDS

Effluent Air

Air effluent limits are established under the CAA NESHAPs. The limit for radiation dose to the public from radioactive emissions is promulgated by EPA and is listed in Table B-1 (see "Air Pathway Only"). Nonradioactive (but otherwise hazardous) material emissions such as beryllium are regulated by the State of Colorado under Colorado Air Quality Control Regulation #8. This regulation sets a limit for beryllium emissions of 10 grams in a 24-hour period per stationary source.

Ambient Air

Ambient air data for nonradioactive particulates have been collected historically at RFP for comparison to criteria pollutants listed under the EPA NAAQS (EPA81) established by the CAA (US83) (Table B-2). Instrumentation and methodology follow requirements established by the EPA in the *Quality Assurance Handbook for Air Pollution Measurement Systems* (EPA76b).

Ambient air data for radioactive particulates are compared with Derived Concentration Guides (DCGs) provided in Table B-3. A further explanation of DCG is given on page 263.

WATER STANDARDS

The most restrictive DCGs for surface-water effluents are provided in Table B-3. A further explanation of DCG guides is provided on page 263.

Table B-1

DOE Radiation Protection Standards for the Public

ICRP-RECOMMENDED STANDARDS FOR ALL PATHWAYS:

Temporary Increase	500 mrem/year EDE (with prior approval of DOE EH-2)
Normal Operations	100 mrem/year EDE

EPA CLEAN AIR ACT NESHAP STANDARDS FOR THE AIR PATHWAY ONLY:

10 mrem/year EDE

Note: In addition to the numerical dose standards listed above, it is the objective of DOE to maintain potential exposures to members of the public to ALARA levels.

Table B-2

National Ambient Air Quality Standards (NAAQS) for Particulates

NAAQS Averaging Time		Concentration
PM-10:	Annual Arithmetic Mean	50 $\mu g/m^3$
	24-hr Average[a]	150 $\mu g/m^3$
TSP[b]:	Annual Geometric Mean	75 $\mu g/m^3$
	24-hr Average	260 $\mu g/m^3$

a. Not to be exceeded more than once per year.
b. TSP no longer used for determining compliance with NAAQS. Sampling and reporting continues for comparison purposes and general interest.

Table B-3

DOE Derived Concentration Guides for Radionuclides of Interest at RFP[a]

Air Inhalation:	Radionuclide	DCG (μCi/ml)
	Plutonium-239, -240	20×10^{-15}
Water Ingestion:	**Radionuclide**	**DCG (μCi/ml)**
	Plutonium-239, -240	30×10^{-9}
	Americium-241	30×10^{-9}
	Uranium-233, -234	500×10^{-9}
	Uranium-238	600×10^{-9}
	Hydrogen-3 (Tritium)	$2{,}000{,}000 \times 10^{-9}$

a. Based on most restrictive assumptions for lung clearance class and gastrointestinal uptake fraction.

Surface-Water Effluent

National Pollutant Discharge Elimination System (NPDES). The NPDES program is a uniform national system, administered by the EPA, which limits the discharge of pollutants into United States surface waters. The RFP NPDES permit expired in 1989 and was extended administratively until renewed. An updated renewal application was submitted. The terms of the permit were modified by the NPDES FFCA signed March 24, 1991, by DOE and EPA, to eliminate two discharge points that were inactive (the Reverse Osmosis Pilot Plant and the Reverse Osmosis Plant) and to include new monitoring parameters at the other discharge locations. NPDES discharge limitations for RFP are provided in Table B-4.

Colorado Water Quality Control Commission Water Quality Standards. The CWQCC established stream standards with some temporary modifications for Segment 5 of Big Dry Creek (tributaries from source to Ponds A-4, B-5, and C-2) as well as stream standards for Segment 4 of Big Dry Creek (from pond outlets to Standley Lake and Great Western Reservoir). These standards became effective in March 1990 with the resegmentation of Big Dry Creek, revised use classifications, and adoption of water quality standards for Woman and Walnut Creek tributaries to Standley Lake and Great Western Reservoir. Stream standards were established for organic and inorganic chemicals, metals, radionuclides, and certain physical and biological parameters (Tables B-5, B-6, and B-7).

A goal qualifier was applied by the CWQCC to Segment 5, indicating that at the time standards were established, the waters were not suitable but are intended to become fully suitable for the classified use. The temporary modifications of ambient quality for Segment 5 are scheduled to expire February 1, 1993. The CWQCC conducted a Rulemaking Hearing in late 1992 and is expected to finalize revised standards in early 1993.

Table B-4

NPDES Permit Limits and Reporting Requirements as modified by the FFCA Effective April 1991[a]

Location/Parameter	Daily Maximum	7-Day Max. Average	30-Day Max. Average
Discharge 001 (Pond B-3)			
Total Suspended Solids (mg/l)	Report[b]	N/A	RPT[b]
Biological Oxygen Demand 5-Day (mg/l)	Report[b]	N/A	RPT[b]
Carbonaceous Biological Oxygen Demand 5-Day (mg/l)	Report[b]	N/A	RPT[b]
Nitrates as N (mg/l)	N/A	20	10
Total Residual Chlorine (mg/l)	0.5	N/A	N/A
Discharge 002 (Pond A-3)			
pH (SU)	9.0[c]	N/A	N/A
Nitrates as N (mg/l)	20	N/A	10
Discharge 005 (Pond A-4)			
Nonvolatile Suspended Solids (mg/l)	Report[b]	N/A	N/A
Flow - million gallons per day (mgd)	Report[b]	N/A	N/A
Whole Effluent Toxicity (LC_{50})[d]	Report[b]	N/A	N/A
Total Chromium (µg/l)	50	N/A	N/A
Discharge 006 (Pond B-5)			
Total Chromium (µg/l)	50	N/A	N/A
Nonvolatile Suspended Solids (mg/l)	Report[b]	N/A	N/A
Flow (mgd)	Report[b]	N/A	N/A
Whole Effluent Toxicity (LC_{50})[d]	Report[b]	N/A	N/A
Discharge 007 (Pond C-2)			
Total Chromium (µg/l)	50	N/A	N/A
Nonvolatile Suspended Solids (mg/l)	Report[b]	N/A	N/A
Flow (mgd)	Report[b]	N/A	N/A
Whole Effluent Toxicity (LC_{50})[d]	Report[b]	N/A	N/A
Discharge STP (995 Effluent)			
pH (SU)	9.0[c]	N/A	N/A
Total Suspended Solids (mg/l)	N/A	45	30
Oil & Grease (mg/l)	No Visual	N/A	N/A
Total Phosphorus (mg/l)	12	N/A	8
Total Chromium (µg/l)	100	N/A	50
Carbonaceous Biological Oxygen Demand 5-Day (mg/l)	25	N/A	10
Total Residual Chlorine (mg/l)	N/A	RPT[b]	RPT[b]
Fecal Coliform (#/100 ml)	N/A	400[e]	200

a. The FFCA also requires reporting but does not specify discharge limitations for the following VOCs and metals: antimony, arsenic, beryllium, cadmium, copper, iron, lead, manganese, mercury, nickel, silver, zinc, benzene, bromoform, carbon tetrachloride, chlorobenzene, chlorodibromomethane, chloroethane, chloroform, dichlorobromomethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, 1,2-dichloropropane, 1,3-dichloropropylene, ethylbenzene, methyl bromide, methyl chloride, methylene chloride, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, 1,2-trans-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, vinyl chloride.

b. Report only, no limitation placed on this analyte by permit.

c. pH daily minimum value = 6.0.

d. WET test results are reported as the percentage of effluent concentration required to cause lethality to half the test organisms within the time period specified (LC_{50}). Ceriodaphnia are tested for 48 hours, fathead minnows for 96 hours.

e. Fecal coliform averages calculated by geometric rather than normal mean.

Table B-5

Colorado Water Quality Control Commission (CWQCC) Water Quality Stream Standards Effective Date - March 30, 1990

Goal Qualifiers, Segment 5 of Big Dry Creek

Chemical Classification	Parameter	CWQCC Standards (mg/l)
Physical and Biological	Dissolved Oxygen	5.0
	pH	6.5 - 9.0
	Fecal Coliforms	2000/100 ml
	Ammonia	
	(Acute)	TVS 0.10
	(Chronic)	0.06
Inorganic	Chlorine	0.019 (ac)
	Cyanide	0.011 (ch)
	Sulfate as Hydrogen Sulfide	.002
	Nitrite	1.0
	Nitrate	10.0
	Chloride	250.0
	Sulfate	250.0
	Boron	.75
Metals	Arsenic	.05
	Cadmium	TVS
	Chromium III	.05
	Chromium VI	TVS
	Copper	TVS
	Iron (Dissolved)	.3
	Iron (Total Recovery)	1.0
	Lead	TVS
	Manganese (Dissolved)	.05
	Manganese (Total Recovery)	1.00
	Mercury	.00001
	Nickel	TVS
	Selenium	.01
	Silver	TVS
	Zinc	TVS

TVS = Table Value Standard

Table B-6

CWQCC Water Quality Stream Standards - Organic Chemical Standards[a] (µg/l)

Parameter	CAS[b] Number	Chronic Standard	Gas Chromatography (GC) Detection Levels
Acrylonitrile	107-1	3-10.058	10[c]
Aldrin	309-00-2	0.000074	0.05
Atrazine		3.0	1
Benzidine	92-87-5	0.00012	10[c]
Chlordane	57-74-9	0.00046	0.5
Chloroform	67-66-3	0.19	0.2/5.0
Chloroethyl Ether BIS	111-44-4	0.0000037	10[c]
DDT	50-29-3	0.000024	0.1
Dichlorobenzidine	91-94-1	0.01	10[c]
Dieldrin	60-57-1	0.000071	0.1
Dioxin (2, 3, 7, 80TCDD)	1746-01-6	0.000000013	
Halomethanes		0.19	
Heptachlor	76-44-8	0.00028	0.5
Hexachloroethane	67-72-1	1.9	1
Hexachlorobenzene	118-74-1	0.00072	1
Hexachlorobutadiene	87-68-3	0.45	0.2/1.0
Hexachlorocyclohexane, Alpha	319-84-6	0.0032	0.05
Hexachlorocyclohexane, Beta	319-85-7	0.0163	0.05
Hexachlorocyclohexane, Gamma (Lindane)	58-89-9	0.0186	0.05
Hexachlorocyclohexane, Technical	608-73-1	0.0123	
Nitrosodibutylamine N		0.0064	5
Nitrosodiethylamine N		0.0008	5
Nitrosodiphenylamine N	86-30-6	4.9	10
Nitrosopyrrolidine N		0.016	10[c]
PCBs	1336-36-3	0.000079	
Simazine		4	0.18
Tetrachloroethane 1, 1, 2, 2	79-34-5	0.17	0.2/5.0
Tetrachloroethane	79-34-5	0.8	0.2/5.0
Trichloroethane 1, 1, 2	79-00-5	0.6	0.2/5.0
Trichlorophenol 2, 4, 6	88-06-2	1.2	1

a. In the absence of specific, numeric standards for nonnaturally occurring organics, the narrative standard "no toxics in toxic amounts" (Section 3.2.22 [1] [d]) shall be interpreted as zero with enforcement based on the practical quantification levels (PQLs) for those compounds as defined by the CWQCC or the EPA.
b. CAS Number is a unique number assigned to a chemical compound by the Chemical Abstract Service of the American Chemical Society.
c. Gas Chromatography/Mass Spectrometry Method.

Table B-7

CWQCC Water Quality Stream Standards - Radionuclides[a]

The radionuclides listed below shall be maintained at the lowest practical level; in no case shall they be increased by any cause attributable to municipal, industrial, or agricultural practices to exceed the site-specific numeric standards.

A. Ambient based site-specific standards:

	Segment 2 Standley Lake	Segment 3 Great Western Reservoir	Segment 4 Segment 5 Woman Creek	Segment 4 Segment 5 Walnut Creek
Gross Alpha	6	5	7	11
Gross Beta	9	12	5	19
Plutonium	.03	.03	.05	.05
Americium	.03	.03	.05	.05
Tritium	500	500	500	500
Uranium	3	4	5	10

B. Other site-specific standards applicable to segments 2, 3, 4, and 5:

Curium-244	60
Neptunium-237	30

a. Statewide standards also apply for radionuclides not listed above. Values listed are in pCi/l.

Drinking Water

The EPA promulgated regulations in 1976 for radionuclides in drinking water (EPA76a). These regulations, along with primary drinking water regulations for microbiological, chemical, and physical contaminants, became effective June 24, 1977. The intent of the Safe Drinking Water Act (SDWA) was to ensure that each state has primary responsibility for maintaining drinking water quality. To comply with these requirements, the CDH modified existing state drinking water standards to include radionuclides (CDH77, CDH81). The following two community drinking water standards are of interest in this report.

1. The state standard for gross alpha activity (including radium-226 but excluding radon and uranium) in community water systems is a maximum of 15 pCi/l or 15 x 10^{-9} µCi/ml (5.6 x 10^{-1} Bq/l). Plutonium and americium, which are alpha-emitting radionuclides, are included in this limit.

2. The limit for tritium in drinking water is 20,000 pCi/l or 20,000 x 10^{-9} μCi/ml (740 Bq/l).

The EPA proposed additional National Primary Water Standards for radionuclides in 1991. These standards have not yet been finalized.

SOIL STANDARDS

There is no standard at the federal level for radionuclides in soil for transuranics. The EPA proposed a screening level for plutonium of 44.4 disintegrations per minute per gram (dpm/g) (19.98 pCi/g) for a soil density of 1 gram per square centimeter (g/cm^2) for soils sampled to a depth of 1 centimeter (0.394 inches) (EPA77).

At the state level, the CDH adopted a standard for plutonium in 1973 of 2.0 dpm/g (0.9 pCi/g) for a soil density of 1 g/cm^2 for soils sampled to a depth of 0.64 centimeters (cm) (1/4 inch) (CDH73).

RADIOLOGICAL DOSE STANDARDS

DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE90a), provides the radiation protection standard for DOE environmental activities. This order, adopted by the DOE on February 8, 1990, incorporates guidance from the ICRP as well as from the EPA Clean Air Act NESHAP standards (as implemented in 40 CFR 61, Subpart H) (US83, EPA85). Included in DOE Order 5400.5 is a revision of the dose limits for members of the public. Tables for radiation dose conversion factors currently used for calculating dose from intakes of radioactive materials were issued in July 1988 (DOE88a, DOE88b). The dose factors are based on the ICRP Publications 30 and 48 methodology and biological models for radiation dosimetry (IN79, IN86). The DOE Order 5400.5 and the dose conversion factor tables are used for assessment of any potential RFP contribution to public radiation dose. In December 1989, EPA published revised CAA NESHAP standards for DOE facilities (EPA89b). DOE radiation standards for protection of the public are given in this Appendix (Table B-1) and include the December 1989 EPA CAA air pathway standards. In addition to the numerical dose limits in DOE Order 5400.5, it is the objective of DOE to maintain potential exposures to members of the public to ALARA levels.

DOE Derived Concentration Guides

Secondary radioactivity concentration guides can be calculated from the primary radiation dose standards and used as comparison values for measured radioactivity concentrations. DOE provides tables of these DCGs in DOE Order 5400.5. DCGs are the concentrations that would result in an EDE of 100 mrem from 1 year's chronic exposure or intake. In calculating air inhalation DCGs, DOE assumes that the exposed individual inhales 8,400 cubic meters of air at the calculated DCG during the year. Ingestion DCGs assume a water intake of 730 liters at the calculated DCG for the year. Table B-3 lists the most restrictive air and water DCGs for the principal radionuclides of interest at RFP.

Plutonium Concentrations. Plutonium concentrations at RFP represent the alpha radioactivity from plutonium-239 and -240. These constitute more than 97 percent of the alpha radioactivity in plutonium used at the plant.

Uranium Concentrations. Uranium concentrations are the cumulative alpha activity from uranium-233, -234, and -238. Components containing fully enriched uranium may be handled at the RFP. Depleted uranium metal can be fabricated and is also handled as a process waste material. Uranium-235 is the major isotope by weight (93 percent) in fully enriched uranium. However, uranium-234 accounts for approximately 97 percent of the alpha activity of fully enriched uranium. In depleted uranium, the combined alpha activity from uranium-234 and -238 accounts for approximately 99 percent of the total alpha activity. Uranium DCGs used in this report for air and water are those for uranium-233, -234, and -238, which are the most restrictive.

Environmental uranium concentrations can be measured by various laboratory techniques. Non-radiological techniques yield concentration units of mass per unit volume such as milligram per cubic meter and milligram per liter. Uranium concentrations given in this report were derived by measuring radioactivity from alpha-emitting uranium isotopes and are expressed in terms of activity units per unit volume. RFP data include measurements of depleted uranium, fully enriched uranium, and natural uranium.

Conversion factors for specific types of uranium can be used to compare the data in this report to data from other facilities and agencies that are given in units of

mass per unit volume; however, the resulting approximations will not have the same assurance of accuracy as that of the original measured values. Uranium in effluent air from plant buildings is primarily depleted uranium. The conversion factor for these data is 2.6 x 10^6 g/Ci. Natural uranium is the predominant species found in water. The conversion factor for water data is 1.5 x 10^6 g/Ci.

Appendix C

WIND STABILITY CLASSES

Table C-1

Wind Frequency Distribution by Percent in 1992, Stability Class A[a]

Wind Speed Classes (Knots)

Wind	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[b]	Total[c]
N	1.1	2.7	0	0	0	0	3.79	0.38
NNE	1.7	5.7	0	0	0	0	7.34	0.73
NE	0.7	11	0	0	0	0	11.72	1.17
ENE	1.3	9.6	0	0	0	0	10.89	1.08
E	1.9	12.2	0	0	0	0	14.08	1.4
ESE	1.9	14.6	0	0	0	0	16.45	1.64
SE	1.2	12.4	0	0	0	0	13.61	1.35
SSE	1.4	4.7	0	0	0	0	6.15	0.61
S	0.8	1.3	0	0	0	0	2.13	0.21
SSW	0.7	1.8	0	0	0	0	2.49	0.25
SW	0.4	1.3	0	0	0	0	1.66	0.16
WSW	0.6	0.9	0	0	0	0	1.54	0.15
W	0.4	0.9	0	0	0	0	1.3	0.13
WNW	0.8	0.9	0	0	0	0	1.78	0.18
NW	0.6	1.7	0	0	0	0	2.25	0.22
NNW	0.9	1.9	0	0	0	0	2.84	0.28
All	16.3	83.7	0	0	0	0	100	9.95

a. Total number of hourly samples in this stability class is 845.
b. Total percent for this stability class.
c. Total percent relative to all stability classes.

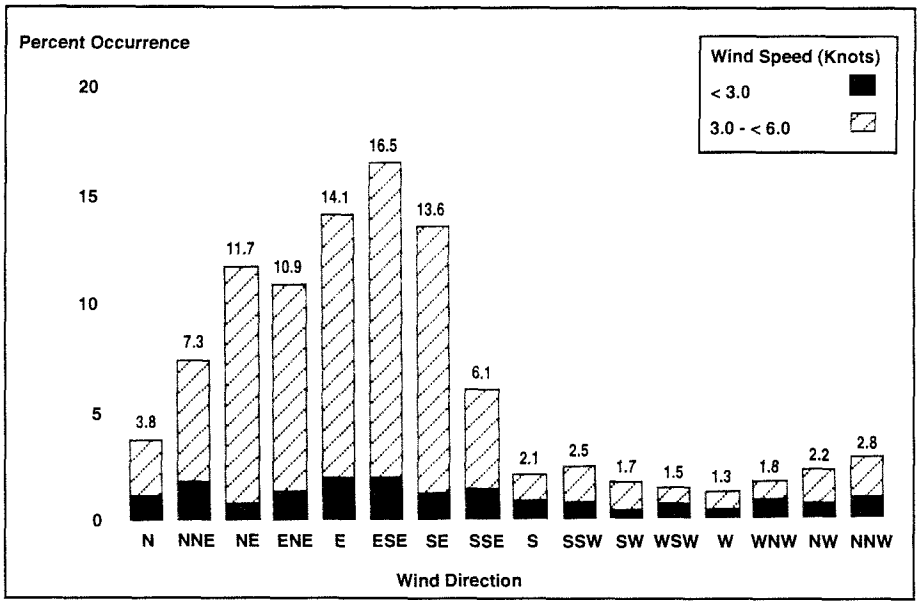

Figure C-1. Stability Class - A

Table C-2

Wind Frequency Distribution by Percent in 1992, Stability Class B[a]

Wind Speed Classes (Knots)

Wind	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[b]	Total[c]
N	0	4	3	0	0	0	7	0.49
NNE	0.3	4.7	4.8	0	0	0	9.83	0.69
NE	0.7	5.5	6	0	0	0	12.17	0.86
ENE	0.2	2.8	5	0	0	0	8	0.57
E	0.8	4.7	3.3	0	0	0	8.83	0.62
ESE	0	5.3	7.5	0	0	0	12.83	0.91
SE	0.3	8	8.3	0	0	0	16.67	1.18
SSE	0.2	4.8	2.7	0	0	0	7.67	0.54
S	0.2	1.7	1.8	0	0	0	3.67	0.26
SSW	0	1	0.5	0	0	0	1.5	0.11
SW	0	0.3	0.8	0	0	0	1.17	0.08
WSW	0.2	0.7	0.8	0	0	0	1.67	0.12
W	0.2	0.7	0.5	0	0	0	1.33	0.09
WNW	0.7	0.7	0.8	0	0	0	2.17	0.15
NW	0.2	0.7	1	0	0	0	1.83	0.13
NNW	0.8	1	1.8	0	0	0	3.67	0.26
All	4.7	46.5	48.8	0	0	0	100	7.06

a. Total number of hourly samples in this stability class is 600.
b. Total percent for this stability class.
c. Total percent relative to all stability classes.

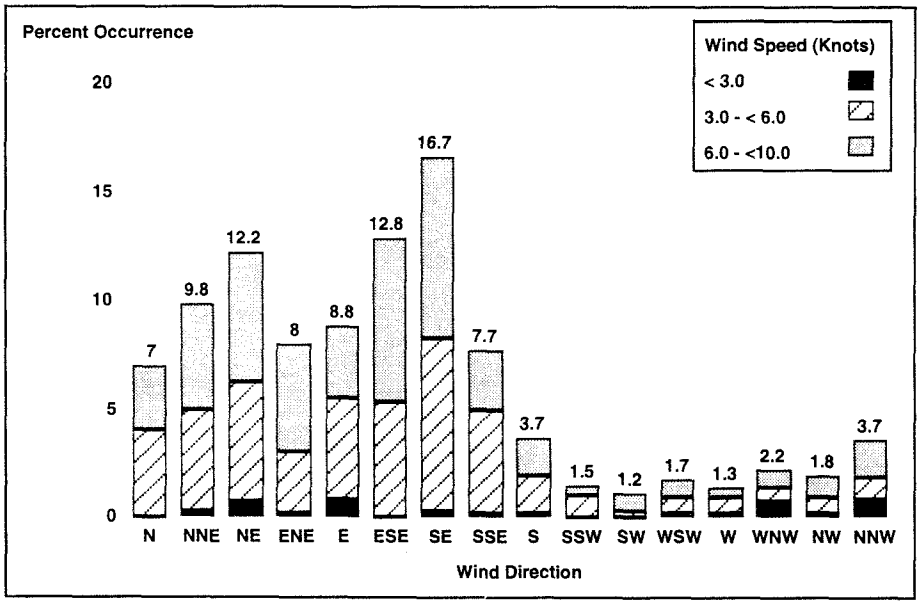

Figure C-2. Stability Class - B

Table C-3

Wind Frequency Distribution by Percent in 1992, Stability Class C[a]

Wind Speed Classes (Knots)

Wind	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[b]	Total[c]
N	0.4	2.9	7.9	1.3	0	0	12.54	1.01
NNE	0.3	2.6	7	1.6	0	0	11.52	0.93
NE	0	3.2	5	0.9	0	0	9.04	0.73
ENE	0	1.2	2.2	0.1	0	0	3.5	0.28
E	0.3	1	2	0	0	0	3.35	0.27
ESE	0.1	3.4	3.9	0	0	0	7.43	0.6
SE	0.1	3.8	7	0.4	0	0	11.37	0.92
SSE	0.1	2.8	6.7	0.3	0	0	9.91	0.8
S	0.1	0.7	1.2	0.1	0	0	2.19	0.18
SSW	0	0.6	1	0.3	0	0	1.9	0.15
SW	0.1	0.7	0.7	0.4	0	0	2.04	0.16
WSW	0	0.7	1.3	0.3	0	0	2.33	0.19
W	0.1	0.4	1.9	1.9	0	0	4.37	0.35
WNW	0.6	0.4	2.5	2.8	0	0	6.27	0.51
NW	0.1	1	2.9	1.3	0	0	5.39	0.44
NNW	0.1	2.2	3.2	1.3	0	0	6.85	0.55
All	2.8	27.7	56.4	13.1	0	0	100	8.08

a. Total number of hourly samples in this stability class is 686.
b. Total percent for this stability class.
c. Total percent relative to all stability classes.

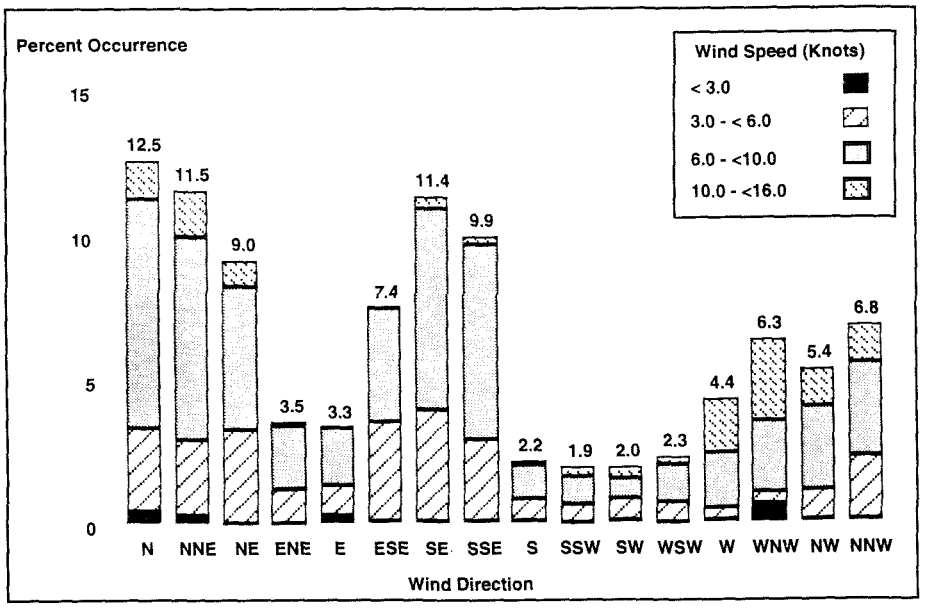

Figure C-3. Stability Class - C

Table C-4

Wind Frequency Distribution by Percent in 1992, Stability Class D[a]

Wind Speed Classes (Knots)

Wind	<3.0	3.0 -<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[b]	Total[c]
N	0.2	2.5	3.1	2.6	0.3	0.1	8.94	3.79
NNE	0.2	1.1	1.6	1.7	0.1	0	4.75	2.01
NE	0.1	0.7	0.9	0.4	0.1	0	2.11	0.89
ENE	0.1	0.7	0.7	0.1	0	0	1.53	0.65
E	0	0.6	0.3	0	0	0	0.94	0.4
ESE	0	0.5	0.3	0	0	0	0.81	0.34
SE	0	0.8	0.6	0.3	0	0	1.69	0.72
SSE	0	1.5	1.7	0.8	0	0	3.97	1.68
S	0.1	1.7	2	0.8	0	0	4.64	1.97
SSW	0.1	1.7	2.1	0.3	0	0	4.19	1.78
SW	0.2	1.7	2.4	1.1	0	0	5.44	2.31
WSW	0.1	1.9	2.9	2.5	0.4	0.1	7.97	3.38
W	0.3	3.4	3.2	3.6	1.8	0.9	13.22	5.6
WNW	0.2	3.1	3.8	7.1	3.5	3	20.63	8.75
NW	0.1	2.4	3.5	3.4	1.2	0.3	10.89	4.62
NNW	0.2	1.8	3.9	2.1	0.3	0	8.28	3.51
All	1.7	26.4	32.8	26.7	7.9	4.5	100	42.39

a. Total number of hourly samples in this stability class is 3601.
b. Total percent for this stability class.
c. Total percent relative to all stability classes.

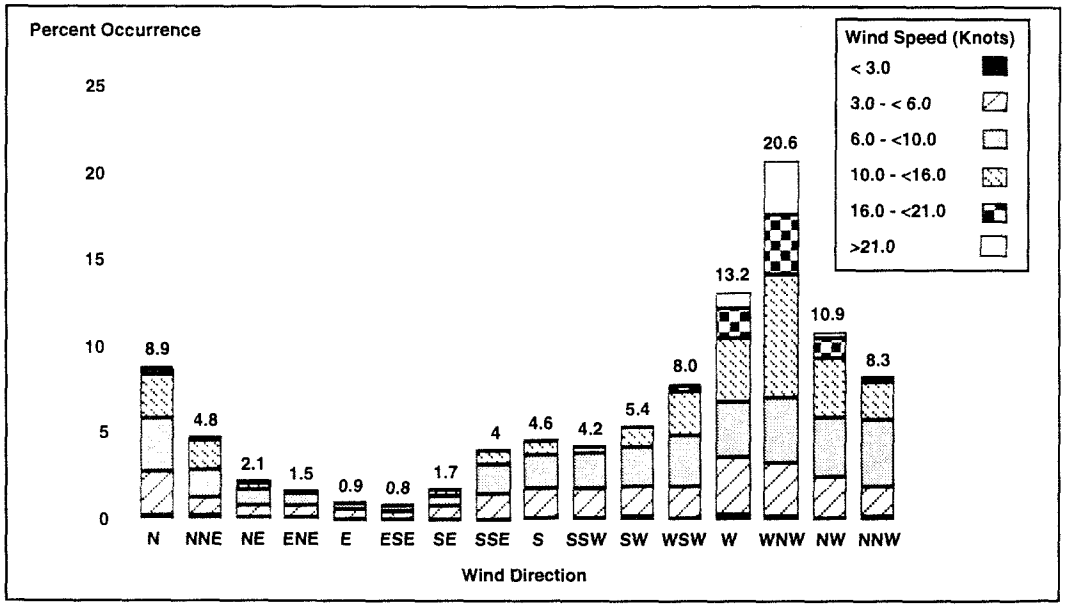

Figure C-4. Stability Class - D

Table C-5

Wind Frequency Distribution by Percent in 1992, Stability Class E[a]

Wind Speed Classes (Knots)

Wind	<3.0	3.0 -<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[b]	Total[c]
N	0.3	2.6	3.6	0.3	0	0	6.89	1.45
NNE	0.4	1.6	1.7	0.2	0	0	3.92	0.82
NE	0.1	0.8	0.7	0	0	0	1.68	0.35
ENE	0.2	0.4	0.6	0	0	0	1.23	0.26
E	0.1	0.9	0.3	0	0	0	1.23	0.26
ESE	0.1	0.6	0.1	0	0	0	0.78	0.16
SE	0.1	0.9	0.4	0.2	0	0	1.63	0.34
SSE	0.1	1.9	1.8	0.2	0	0	4.04	0.85
S	0.3	2.9	3.6	0.1	0	0	6.84	1.44
SSW	0.2	3.1	5	0	0	0	8.3	1.74
SW	0.7	4.4	6.5	0	0	0	11.55	2.43
WSW	0.7	5.2	9.2	0.1	0	0	15.13	3.18
W	0.6	5.4	2.9	0	0	0	8.86	1.86
WNW	0.6	4.2	2	0.1	0	0	6.78	1.42
NW	0.5	5.3	4.2	0.1	0	0	10.03	2.11
NNW	0.7	3.9	6.3	0.2	0	0	11.1	2.33
All	5.7	44.1	48.9	1.3	0	0	100	21

a. Total number of hourly samples in this stability class is 1784.
b. Total percent for this stability class.
c. Total percent relative to all stability classes.

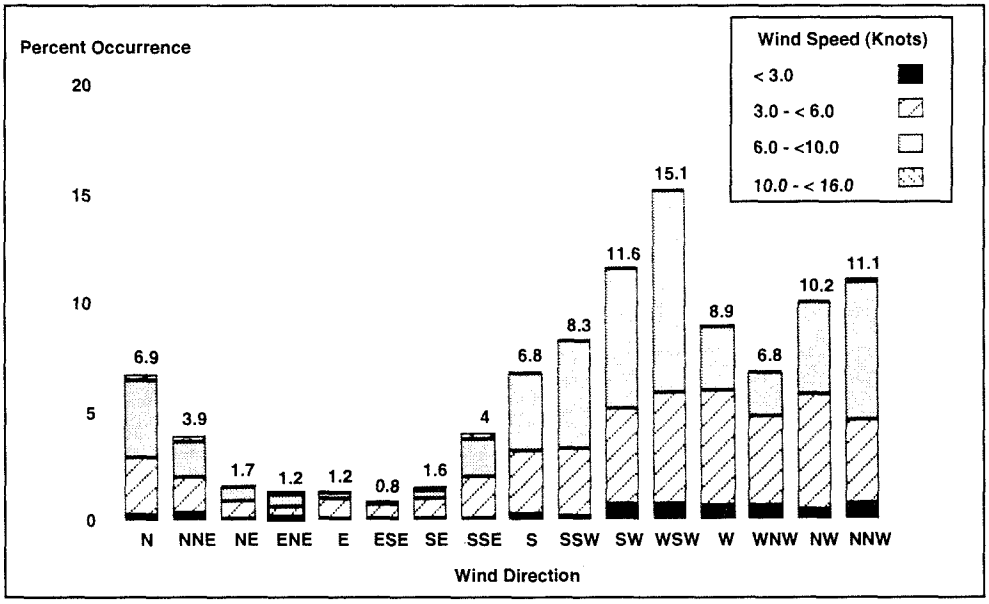

Figure C-5. Stability Class - E

Table C-6

Wind Frequency Distribution by Percent in 1992, Stability Class F[a]

Wind Speed Classes (Knots)

Wind	<3.0	3.0 -<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[b]	Total[c]
N	0.9	4	0	0	0	0	4.91	0.57
NNE	1.2	2.1	0	0	0	0	3.37	0.39
NE	1	2.1	0	0	0	0	3.17	0.36
ENE	0.9	1.7	0	0	0	0	2.66	0.31
E	0.6	3.4	0	0	0	0	3.99	0.46
ESE	1.3	2.4	0	0	0	0	3.68	0.42
SE	0.7	2.9	0	0	0	0	3.58	0.41
SSE	1.3	4	0	0	0	0	5.32	0.61
S	1.6	5.4	0.8	0	0	0	7.87	0.91
SSW	2	4.2	0.2	0	0	0	6.44	0.74
SW	2	7.8	0.2	0	0	0	10.02	1.15
WSW	2.1	6.7	0.1	0	0	0	9	1.04
W	2.1	6	0	0	0	0	8.18	0.94
WNW	2.7	6.6	0	0	0	0	9.3	1.07
NW	3.4	7.2	0	0	0	0	10.53	1.21
NNW	3.1	4.8	0	0.1	0	0	7.98	0.92
All	27.2	71.4	1.3	0.1	0	0	100	11.51

a. Total number of hourly samples in this stability class is 978.
b. Total percent for this stability class.
c. Total percent relative to all stability classes.

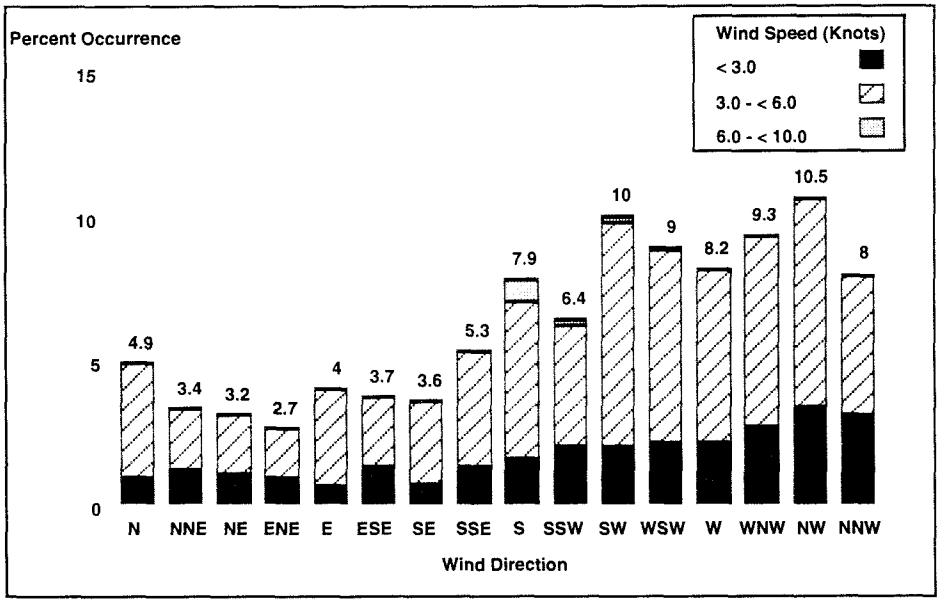

Figure C-6. Stability Class - F

Table C-7

Wind Frequency Distribution by Percent in 1992, Stability Class All [a]

Wind Speed Classes (Knots)

Wind	<3.0	3.0 -<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[b]	Total[c]
N	0.4	2.9	2.9	1.3	0.1	0	7.69	7.69
NNE	0.5	2.2	1.9	0.9	0	0	5.58	5.58
NE	0.3	2.4	1.3	0.2	0.1	0	4.37	4.37
ENE	0.3	1.8	0.9	0	0	0	3.14	3.14
E	0.4	2.4	0.6	0	0	0	3.41	3.41
ESE	0.4	2.7	1	0	0	0	4.07	4.07
SE	0.3	3	1.5	0.2	0	0	4.92	4.92
SSE	0.3	2.5	1.8	0.4	0	0	5.1	5.1
S	0.4	2.3	1.9	0.4	0	0	4.96	4.96
SSW	0.4	2.2	2.1	0.2	0	0	4.77	4.77
SW	0.5	2.8	2.5	0.5	0	0	6.3	6.3
WSW	0.5	2.9	3.4	1.1	0.2	0	8.05	8.05
W	0.5	3.5	2.1	1.7	0.8	0.4	8.98	8.98
WNW	0.7	3.2	2.3	3.2	1.5	1.3	12.08	12.08
NW	0.6	3.3	2.7	1.6	0.5	0.1	8.72	8.72
NNW	0.7	2.6	3.3	1	0.1	0	7.85	7.85
All	7.2	42.5	32.3	12.7	3.3	1.9	100	100

a. Total number of hourly samples in all stability classes is 8494.
b. Total percent for this stability class.
c. Total percent relative to all stability classes. Annual data recovery = 96.7 percent.

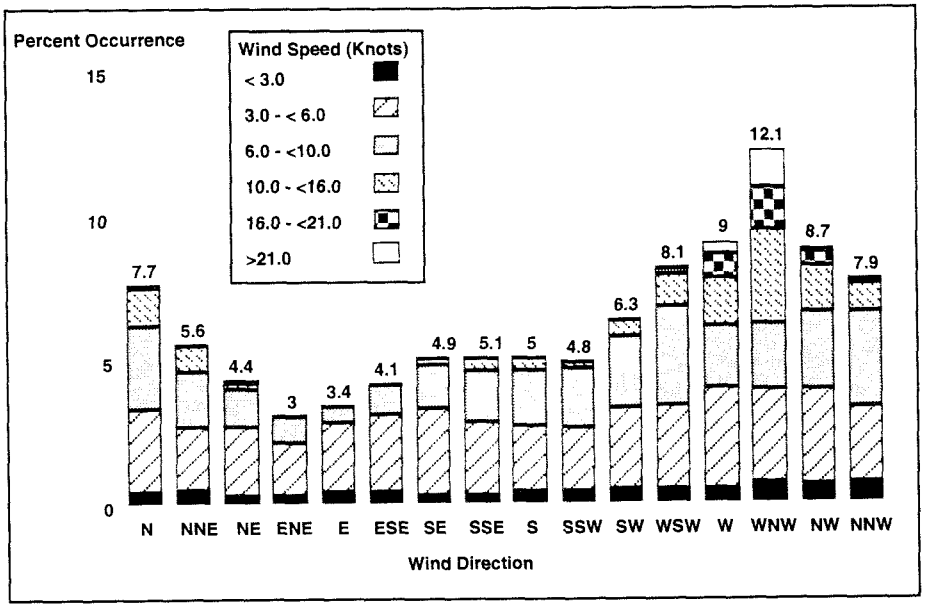

Figure C-7. Stability Class - All

Appendix D

ANALYTICAL PROCEDURES

ENVIRONMENTAL RADIOCHEMISTRY LABORATORY

The Environmental Radiochemistry Laboratory routinely performs analyses on the environmental and effluent samples described below.

1. Total Air Filter Counting (long-lived alpha)
2. Gas Proportional Counting (gross alpha and gross beta)
3. Alpha Spectral Analysis (Plutonium-239, -238; Americium-241; Uranium-238, -233, -234)
4. Beta Liquid Scintillation (Tritium)
5. Atomic Absorption (Beryllium)
6. Millipore Filtration Method (Fecal and Total Coliform)

Procedures for these analyses are described in the *Radiological Health Procedures and Practices Manual* (WI82). The procedures for bacteria and chlorine analyses were developed following EPA guidelines. Soil procedures were developed following specifications set forth in *Measurements of Radionuclides in the Environment, Sampling and Analysis of Plutonium in Soil*, Nuclear Regulatory Commission (NRC) Regulatory Guide 4.5. All new procedures and changes to existing procedures must be thoroughly tested, documented, and approved in writing by the manager of the Environmental Radiochemistry Laboratory before being implemented. Environmental Protection Management (EPM) is notified of any major changes that could affect analytical results. All procedures are reviewed annually (or at any time an analytical problem is suspected) for consistency with state-of-the-art techniques. Copies of all procedures are kept on file in the office of the manager of Environmental Radiochemistry Laboratories.

Analytical Procedures

Samples received for air filter screening are counted approximately 24 hours and then 48 hours after collection. Samples exceeding specified limits are recounted. If the total long-lived alpha concentration for a screened filter exceeds specified action limits, the filter is directed to individual specific isotope analysis and/or follow-up investigation to determine the cause and any needed corrective action.

All water samples, except those scheduled for tritium analysis, are poured into 1-liter Marinelli containers and sealed before delivery to the gamma counting area. Routine water samples are counted for approximately 12

hours. Samples requiring a lower detection limit are counted from 16 to 72 hours.

Soil samples scheduled for gamma spectral analysis are dried, put through a 10-mesh sieve, weighed, and the final portion is ball-milled. The fine portion is then placed in a 500-milliliter Marinelli container and counted for at least 16 hours.

All samples scheduled for alpha spectral analysis are analyzed in a similar manner regardless of matrix. Before dissolution, a known quantity of nonindigenous radioactive tracer is added to each sample. The tracer is used to determine the chemical recovery for the analysis. Tracers used include plutonium-236, americium-243, and curium-244. The type and activity level of the tracer used depends on the type and projected activity level of the sample to be analyzed. All refractory or intractable actinides are dissolved by vigorous acid treatment using both oxidizing and complexing acids. After samples are dissolved, the radioisotopes of concern are separated from each other and from the matrix material by various solvent extraction and ion exchange techniques. The purified radioisotopes are electro-deposited onto stainless steel discs. These discs are alpha counted for 12 hours. If a lower minimum detection limit is required, samples may be counted from 72 to 168 hours, depending on the specific sensitivity requirements. Samples that exhibit a chemical recovery of less than 10 percent or greater than 105 percent are automatically scheduled for reanalysis.

Tritium analyses are routinely performed on specified environmental water samples, as well as on stack effluent samples. Ten milliliters of the samples are combined with 10 milliliters of liquid scintillation fluid. Effluent samples are counted for 30 minutes, while environmental samples are counted for 45 minutes.

GENERAL LABORATORY

The General Laboratory routinely performs several analyses in support of environmental monitoring of plant effluent streams, process wastes, and soil residues. The analyses routinely performed are provided below.

1. Metallic elements including tests for 19 cations by inductively coupled plasma spectroscopic techniques and 10 elements by atomic absorption spectroscopy techniques (including beryllium in airborne effluent sample filters).

2. Oxygen demand tests on water including total organic carbon, dissolved oxygen, chemical oxygen demand, carbonaceous biological oxygen demand, and biological oxygen demand (5-day incubation).

3. Nutrient tests including free ammonia, ortho and total phosphate phosphorus, nitrite, and nitrate anions.

4. Physical tests including pH, conductivity, color, total dissolved solids, suspended solids, total solids, nonvolatile suspended solids, turbidity, and specific gravity.

5. Soap residues (as alkyl sulfonate).

6. Oil and grease residues, by extraction and infrared or gravimetric detection, and by visual observation.

7. Specific chemical property or element including total hardness (as calcium carbonate), alkalinity (as hydroxide, bicarbonate, or carbonate), chloride, fluoride, cyanide, sulfate, and hexavalent chromium.

8. Gross alpha and gross beta analyses by gas proportional counting.

9. Volatile and semivolatile compounds from the EPA Contract Laboratory Program (CLP) Target Analyte List are analyzed by gas chromatography/mass spectrometry. Phenols also are analyzed using spectrophotometry. Polychlorinated biphenyl compounds are analyzed by gas chromatography.

10. Toxicity Characteristic Leaching Procedure (TCLP) extractable metals and organics for compliance to land ban restrictions.

Procedures for these analyses, developed by the General Laboratory analytical technical staff, were adopted from EPA-approved sources or from other recognized authoritative publications where EPA-approved procedures were not available. Laboratory operations procedures are documented in a standard format, approved by the manager of the Rocky Flats Analytical Laboratories, and issued to a controlled distribution list to ensure that proper testing and approval is performed before changes are adopted. The Analytical Laboratories Quality Assurance Plan requires annual

review of procedures for consistency with state-of-the-art techniques and compliance of laboratory practice with written procedures. In addition, a review is performed whenever an analytical problem is indicated.

Analytical Procedures

Water samples to be tested for chemical and physical parameters are preserved and/or refrigerated, when required. The tests performed include gravimetric, titrametric, calorimetric, chromatographic, or electro-analytical methods, following procedures specified in the 17th edition of *Standard Methods for the Examination of Water and Waste Water, Methods for Chemical Analysis of Water and Wastes*, EPA-SW846, or other authorative publications.

All water samples analyzed for gross alpha/gross beta are acidified immediately upon collection to pH less than 2 using nitric acid.

Gross alpha and gross beta activities of liquid samples are measured by evaporating an aliquot onto a stainless steel counting planchet and counting in a low background, thin-windowed, gas flow proportional counter. Two planchets are prepared for each sample and the average and propagated uncertainty of the two counts are reported. The detector counting efficiency and self-absorption effects of the salt residue on the planchet are determined from calibration curves using known alpha and beta standards and increasing amounts of salt. Americium-241 is used to generate the alpha curve and strontium-90 is used for the beta curve.

Water samples to be analyzed for metal ions are preserved with nitric acid and are digested before being analyzed by atomic absorption or inductively coupled plasma (ICP) methods. Organic toxic species are determined by Gas Chromatograph/Mass Spectrometry/Data Systems following EPA protocol for volatile organics and semivolatile organics. Some organics, such as phenol, are determined by developing achromaphoric complex and measuring light absorption at a specific wavelength with a spectrophotometer. Measuring occurs after extraction into an appropriate solvent phase.

DETECTION LIMITS AND ERROR TERM PROPAGATION

Radioactivity Parameters

The Environmental Radiochemistry Laboratory has adopted the following definition for detection limit for isotopic specific analyses, as given by Harley (HA72).

"The smallest amount of sample activity using a given measurement process (i.e., chemical procedure and detector) that will yield a net count for which there is confidence at a predetermined level that activity is present."

The minimum detectable amount (MDA) is the term used to describe the detection limit and is defined as the smallest amount of an analyzed material in a sample that will be detected with a "β" probability of non-detection (Type II error), while accepting an "α" probability of erroneously detecting that material in an appropriate blank sample (Type I error). In the formulation below, both α and β are equal to 0.05.

Based on the approach presented in draft ANSI Standard N13.30, *Performance Criteria for Radiobioassay* (HE85), the formulation of the MDA for radioactive analyses is:

$$MDA = \frac{4.65\ S_B + 2.71/(T_S E_S Y)}{aV}$$

where S_B = standard deviation of the population of appropriate blank values (disintegrations per minute, d/m)

T_S = sample count time (minutes, m)

E_S = absolute detection efficiency of the sample detector

Y = chemical recovery for the sample

a = conversion factor (disintegrations per minute per unit activity)

(a = 2.22 disintegrations per minute per picocurie [d/m/pCi] when MDA is in units of pCi, and a = 2.22 x 10^6 disintegrations per minute per microcuries [d/m/μCi] when MDA is in units of μCi)

V = sample volume or weight (V=1 if the MDA per sample is desired)

The major component of the MDA equation is the variability of the blanks.

Table D-1 shows the various formulas used for alpha data reduction during 1992. Table D-2 shows the typical MDA values for the various analyses performed by the Environmental Radiochemistry Laboratories. These values are based on the average sample volume, typical detector efficiency, detector background, count time, and chemical recovery. MDA values calculated for individual analyses may vary significantly depending on actual sample volume, chemical recovery, and analytical blank used.

Nonradioactivity Parameters

For nonradioactivity parameters, various means are used to estimate a minimum detection limit (MDL) depending on the parameter measured. MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. The MDL for beryllium in effluent air, analyzed using flameless atomic absorption spectroscopy, is based on a sample blank absorbance reading. Total chromium in effluent water samples undergoes a fourfold concentration of the received sample prior to its analysis using flame atomic absorption spectroscopy. Its approximate MDL is based on a net sample absorbance reading of 0.010.

The parameters of nitrate as N, total phosphorous, suspended solids, oil and grease, and total organic carbon have MDLs determined by procedural methods found in EPA-600, *Environmental Monitoring and Support Laboratory, Methods for Chemical Analysis of Water and Wastes* (EPA87b). Biochemical oxygen demand and pH have MDLs determined by the minimal readout capability of the instrumentation that is used. The MDL for residual chlorine is determined by the procedure found in a publication by Hach Company, *DPD Method for Chlorine* (HA83). For fecal coliform count, MDL is calculated as 4.65 times the standard deviation of the blank value from the millipore filter.

REPORTING OF MINIMUM DETECTABLE CONCENTRATION AND ERROR TERMS

Plutonium, uranium, americium, tritium, and beryllium measured concentrations are given in this report. Most of the measured concentrations are at or very near background levels, and often there is little or no amount of

Table D-1

Formulas for Activity and Uncertainty Calculations for the Alpha Spectral Analysis Systems

Nonblank Corrected Sample Activity

$$A_{si} = \frac{\left[\frac{C_{si}}{T_s} - \frac{C_{Bi}}{T_B}\right]}{\left[\frac{C_{sj}}{T_s} - \frac{C_{Bj}}{T_B}\right]} \quad \frac{D_{sj}}{V \cdot 2.22}$$

Blank Corrected Sample Activity

$$B_{si} = A_{si} - A_{ri}$$

Nonblank Corrected Sample Uncertainty*

$$a_{si} = A_{si}\left[\frac{\frac{C_{si}}{T_s^2} + \frac{C_{Bi}}{T_B^2}}{\left[\frac{C_s}{T_s} - \frac{C_{Bi}}{T_B}\right]^2} + \frac{\frac{C_{sj}}{T_s^2} + \frac{C_{Bj}}{T_B^2}}{\left[\frac{C_{sj}}{T_s} - \frac{C_{Bj}}{T_B}\right]^2}\right]^{1/2}$$

Blank Corrected Sample Uncertainty

$$b_{si} = (a_{si}^2 + a_{ri}^2)^{1/2}$$

*Sample uncertainty is the propagated standard deviation of sample activity using counting statistics.

A_{ri} = Nonblank corrected activity of laboratory reagent blank for isotope i expressed as picocuries (pCi) per unit volume.
a_{ri} = Nonblank corrected uncertainty of laboratory reagent blank expressed as pCi per unit volume.
A_{si} = Sample activity for isotope i expressed as pCi per unit volume.
a_{si} = Sample activity uncertainty expressed as pCi per unit volume.
B_{si} = Blank corrected sample activity for isotope i expressed as pCi per unit volume.
b_{si} = Blank corrected sample uncertainty expressed as pCi per unit volume.
D_{sj} = Activity (dpm) of internal standard isotope j added to sample.
C_{si} = Sample gross counts for isotope i.
C_{sj} = Sample gross counts for internal standard isotope j.
C_{Bi} = Detector background gross counts for isotope i.
C_{Bj} = Detector background gross counts for internal standard isotope j.
T_s = Sample count time expressed in minutes.
T_B = Detector background count time expressed in minutes.
V = Sample unit volume or sample unit weight.

Table D-2

Typical Detection Limits for Radioactive and Nonradioactive Materials

Parameter	Minimum Detectable Activity (per sample)	Approximate Sample Volume Analyzed[a]	Minimum Detectable Activity (per unit volume or mass)
Airborne Effluents			
Plutonium-239, -240	5.9×10^{-8} µCi	7,340 m^3 [b]	0.008×10^{-15} µCi/ml
Uranium-233, -234	1.3×10^{-7} µCi	7,340 m^3 [b]	0.018×10^{-15} µCi/ml
Uranium-238	1.4×10^{-7} µCi	7,340 m^3 [b]	0.020×10^{-15} µCi/ml
Americium-241	4.3×10^{-8} µCi	7,340 m^3 [b]	0.006×10^{-15} µCi/ml
Tritium (H-3)	2.1×10^{-6} µCi	1.4 m^3	$1,530 \times 10^{-15}$ µCi/ml
Beryllium	2.5×10^{-1} µCi	7,340 m^3 [b]	3.0×10^{-5} µg/m^3
Ambient Air Samples			
Plutonium-239, -240	9.7×10^{-8} µCi	29,000 m^3 [c]	0.003×10^{-15} µCi/ml
Effluent Water Samples (Radioactive)			
Plutonium-239, -240	8.1×10^{-8} µCi	1,000 ml	0.81×10^{-10} µCi/ml[c]
		7,000 ml	0.12×10^{-10} µCi/ml[c]
Uranium-233, -234	0.15×10^{-6} µCi	1,000 ml	0.15×10^{-9} µCi/ml[c]
Uranium-238	0.15×10^{-6} µCi	1,000 ml	0.15×10^{-9} µCi/ml[c]
Americium-241	6.2×10^{-8} µCi	1,000 ml	0.62×10^{-10} µCi/ml[c]
		7,000 ml	0.089×10^{-10} µCi/ml[c]
Tritium (H-3)	2.1×10^{-6} µCi	10 ml	2.14×10^{-7} µCi/ml[c]
Soil Samples (Radioactive)			
Plutonium-239, -240	0.03 pCi/gm	1-5 gm	
Effluent Water Samples (Nonradioactive)			Minimum Detection Limit
pH		100 ml	0-14 SU
Nitrates as N		4 ml	0.02 mg/l
Total Phosphorus		50 ml	0.01 mg/l
Biochemical Oxygen Demand, 5-Day		300 ml	5.0 mg/l
Suspended Solid		100 ml	4.0 mg/l
Total Chromium		100 ml	0.01 mg/l
Residual Chlorine		10 ml	0.1 mg/l
Oil and Grease		1,000 ml	0.5 mg/l
Fecal Coliform Count		100 ml	1 colony/100 ml
Total Organic Carbon		5 ml	5.0 mg/l

a. Volume analyzed is usually an aliquoted fraction of the total sample volume collected.
b. Monthly composite.
c. Composite of two biweekly samples.

these materials in the media being analyzed. When this occurs, the results of the laboratory analyses can be expected to show a statistical distribution of positive and negative numbers near zero and numbers that are less than the calculated minimum detectable concentration for the analyses. The laboratory analytical blanks, used to correct for background contributions to the measurements, show a similar statistical distribution around their average values. Negative sample values result when the measured value for a laboratory analytical blank is subtracted from a sample analytical result that is smaller than the analytical blank value. Results that are less than calculated minimum detectable levels indicate that the results are below the level of statistical confidence in the actual numerical values. All reported results, including negative values and values that are less than minimum detectable levels, are included in any arithmetic calculations on the data set. Reporting all values allows all of the data to be evaluated using appropriate statistical treatment. This assists in identifying any bias in the analyses, allows better evaluation of distributions and trends in environmental data, and helps in estimating the true sensitivity of the measurement process.

The reader should use caution in interpreting individual values that are negative or less than minimum detectable levels. A negative value has no physical significance. Values less than minimum detectable levels lack statistical confidence as to what the actual number is, although it is known with high confidence that it is below the specified detection level. Such values should not be interpreted as being the actual amount of material in the sample, but should be seen as reflecting a range from zero to the minimum detectable level, in which the actual amount would likely lie. These values are significant, however, when taken together with other analytical results that indicate that the distribution is near zero.

Error terms in the form of a±b are included with some of the data. For a single sample, "a" is the analytical blank corrected value; for multiple samples, "a" represents the average value (arithmetic mean). The error term "b" accounts for the propagated statistical counting uncertainty for the sample and the associated analytical blanks at the 95 percent confidence level. These error terms represent a minimum estimate of error for the data.

Appendix E

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METRIC FRACTIONS

Multiple	Decimal Equivalent	Prefix	Symbol
10^6	1,000,000	mega-	M
10^3	1,000	kilo-	k
10^2	100	hecto-	h
10	10	deka-	da
10^{-1}	0.1	deci-	d
10^{-2}	0.01	centi-	c
10^{-3}	0.001	milli-	m
10^{-6}	0.000001	micro-	μ
10^{-9}	0.000000001	nano-	n
10^{-12}	0.000000000001	pico-	p
10^{-15}	0.000000000000001	femto-	f
10^{-18}	0.000000000000000001	atto-	a

METRIC CONVERSION TABLE

Multiply	By	Equals	Multiply	By	Equals
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
ac	0.404	ha	ha	2.47	ac
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liq. qt. - U.S.	0.946	l	l	1.057	liq. qt. - U.S.
ft^2	0.093	m^2	m^2	10.764	ft^2
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.31	ft^3
d/m	0.450	pCi	pCi	2.22	d/m
pCi/l (water)	10^{-9}	μCi/ml (water)	μCi/ml (water)	10^9	pCi/l (water)
pCi/m^3 (air)	10^{-12}	μCi/cc (air)	μCi/cc (air)	10^{12}	pCi/m^3 (air)

TRADITIONAL AND INTERNATIONAL SYSTEMS OF RADIOLOGICAL UNITS

(Traditional units are in parentheses.)

Quantity	Name	Symbol	Expression in Terms of Other Units
absorbed dose	Gray	Gy	J/Kg^{-1}
	(rad)	rad	10^{-2} Gy
activity	Becquerel	Bq	1 dps
	(curie)	Ci	3.7×10^{10} Bq
dose equivalent	Sievert	Sv	J/Kg^{-1}
	(rem)	rem	10^{-2} Sv
exposure	Coulomb per kilogram		C/Kg^{-1}
	(roentgen)	R	2.58×10^{-4} C/Kg-1